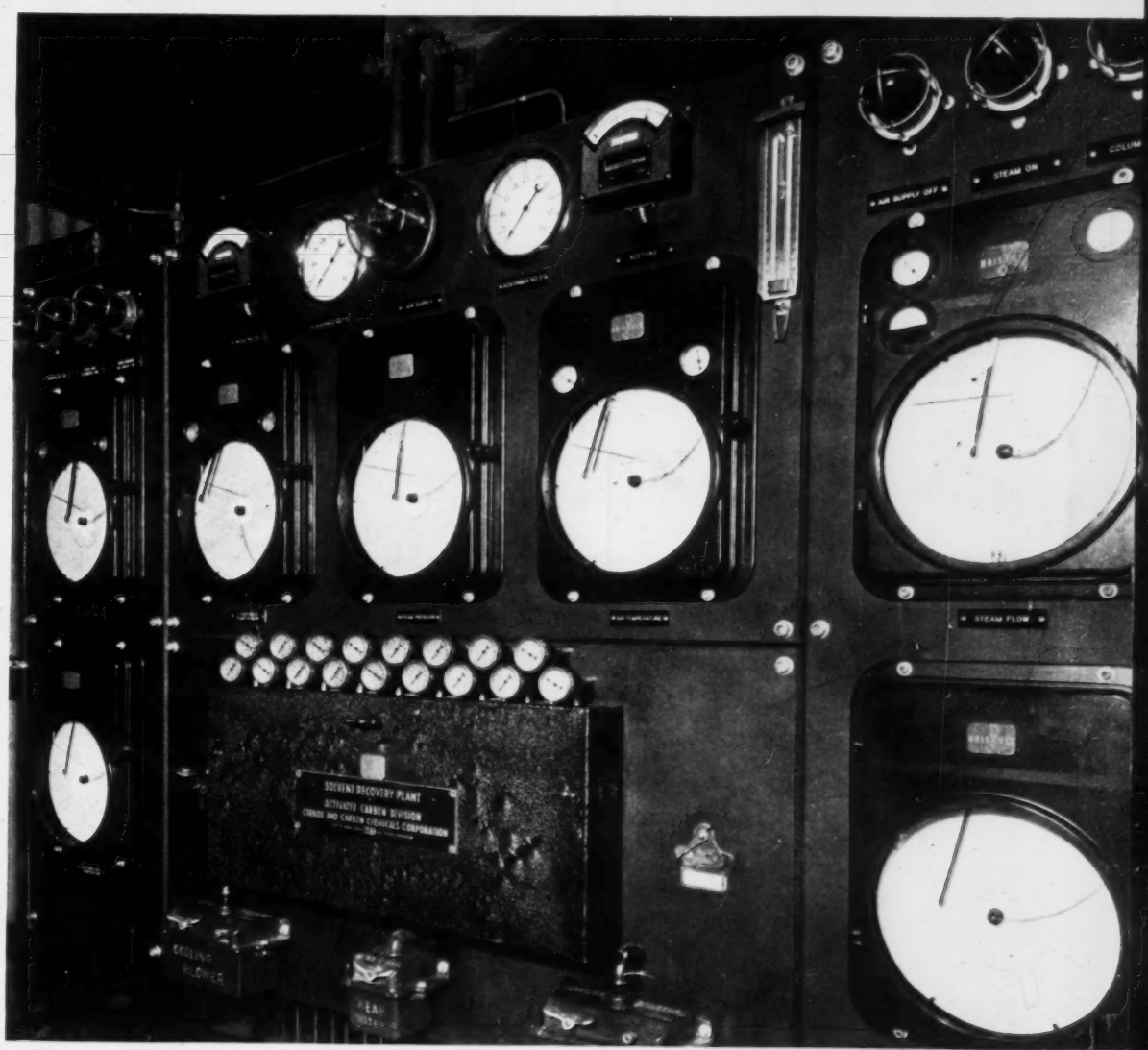
THE MAGAZINE OF

INSTRUMENTS and MEASUREMENT CONTROL



Instrumentation of Solvent Recovery Plant, Endicott-Johnson Corporation, Johnson City, N. Y.
Courtesy Activated Carbon Div., Carbide & Carbon Chemicals Corp.

Beginning In This Issue . . . . . A NEW DEPARTMENT

ABOUT YOU AND YOUR WORK *See page 1*

VOLUME 9
JAN. 1936
NUMBER 1

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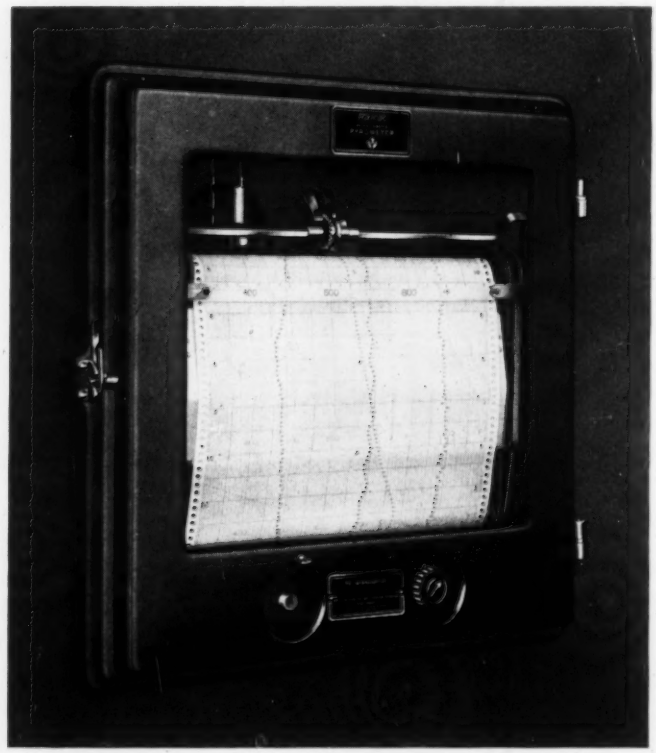

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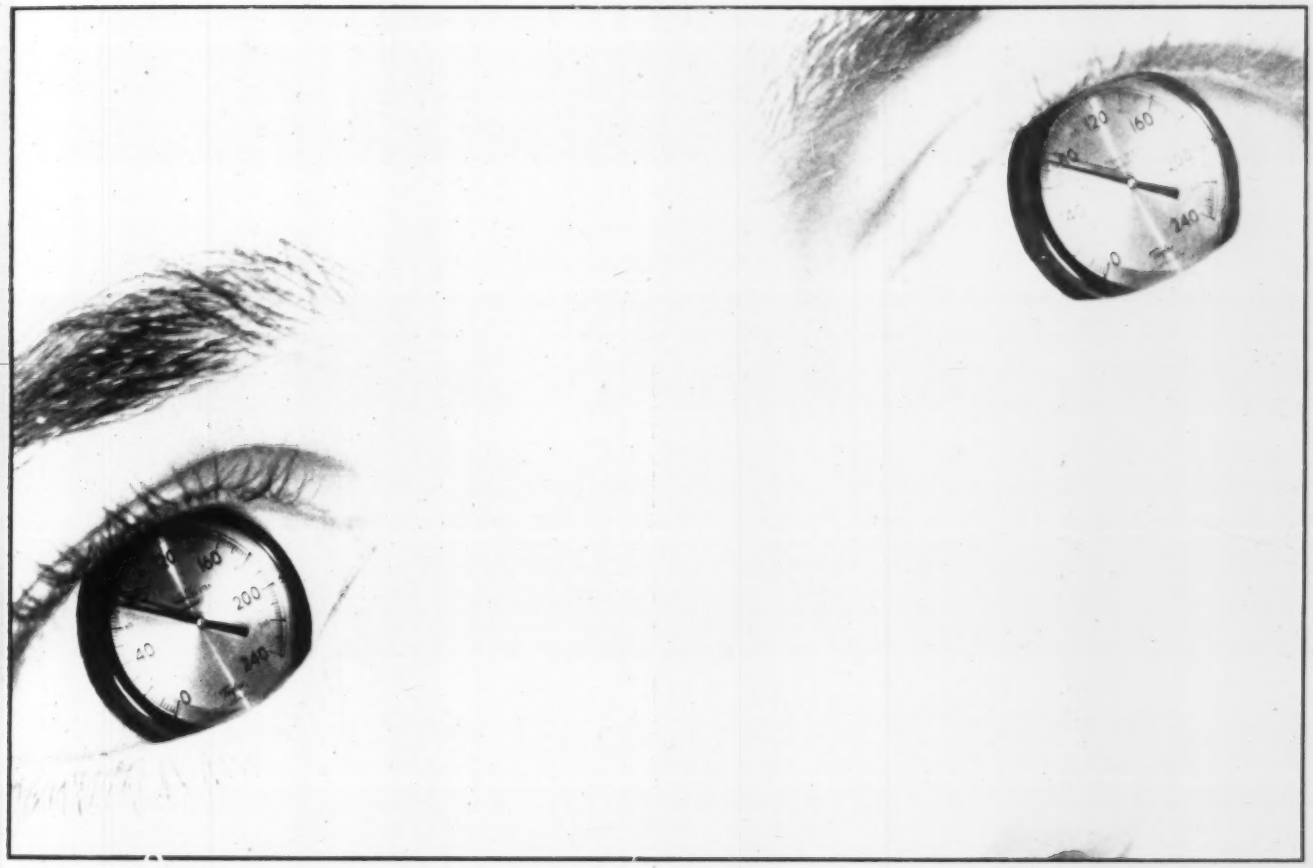

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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

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Courtesy Carbide & Carbon

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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

M. F. BEHAR
EDITOR

IN THIS ISSUE

Many months ago it already was true that no bibliography on flow measurement could claim to be complete which did not include references to important articles appearing exclusively in *Instruments*. To the galaxy of eminent authorities who are contributing these articles, the name of J. J. Mikita may now be added.—*Pages 2-3.*

Instrumentation without "instruments"—this paradox is sometimes found in automatic-control installations. A voltage-regulation example is described by G. F. Lampkin.—*Pages 4-5.*

R. R. Batcher begins a treatment of cathode-ray tube auxiliaries.—*Pages 6-9.*

Human interest in *Instruments?* Why not? Henceforth, as explained in the adjoining column, a brief biography each month.—*Page 10.*

The series on telemetering concludes with discussions of "impulse" systems.—*Pages 11-23.*

Book Reviews have not been given up. In addition to this month's crop (*page 9*) there will be many more.

The same is true of New Instruments (*pages 24-30*): so many items are coming in that February may set a new record.

INNOVATIONS

SOME creative workers, when undertaking a new painting, play or poem, brush off mental cobwebs and gain the proper frame of mind by deliberately changing all their clothes. In other instances, a change of attire is but the unplanned outward manifestation of an inner conversion or growth. No philosophical subtleties, however, are needed to interpret this magazine's most apparent change of dress—consisting of making the words MEASUREMENT AND CONTROL as prominent as the word INSTRUMENTS. It simply reflects the relative degrees of emphasis on *means* and on *ends* which we once summed up as follows:

Let us start by considering what binds us together. Meters and gages? No: more than instruments. Instrumentation.[1]

Moreover, there has been no sudden change in editorial policy. On the contrary, it has been a long evolution, which manifested itself once before in an equally conspicuous change on the front-cover just four years ago, when the original title INSTRUMENTS INDUSTRIAL—SCIENTIFIC became INSTRUMENTS THE MAGAZINE OF MEASUREMENT AND CONTROL.

To feel that, having found our niche, we can sit back and let things ride, would be folly. Accordingly, in addition to greater emphasis on your measurement and control problems, we are inaugurating a department devoted to your chief interests: yourself and your work. A composite "you" would be as colorless as "the average American," so we shall from month to month feature you, and you, and you. . . . This innovation, too, reflects an underlying conviction which we never have hesitated to proclaim openly:

We are all colleagues in one esteemed profession: all [instrumenticians] belong to one fraternity that strives to make better things for mankind and to eliminate human drudgery.[2]

It may be too early to assert that the four thousand of "you" are as unified and influential as, say, the members of an old engineering or legal or medical National Society, but the series of sketches now beginning on page 10 with a "typical plant instrumentician" (Charter Subscriber C. E. Fry) will in time bring out your common traits.

In the "New Instruments" Department the noticeable sudden innovation (maker's name and address at end of each item) reflects a gradual compliance by manufacturers with our desire to have you supplied with the data *you* want to know.

[1]First paragraph of Preface of *The Manual of Instrumentation*.
[2]Editorial in June 1933 *Instruments*.

Calibration of Small Venturi Meters

By J. J. MIKITA

Research Assistant, Department of Mechanical Engineering, The Pennsylvania State College

DURING an investigation of the performance of lubricating oils in automobile engines[1] it was necessary to measure the rates of flow of lubricating oil through four engines under test. For this purpose four Venturi tubes having throat diameters of 3/16" and entrance diameters of 3/8" were constructed. Since a search of the technical literature revealed insufficient data on small Venturi meters for viscous liquids, it was decided to make a thorough calibration of one of the Venturis over the flow and viscosity range encountered in the engines. As was expected, the Venturi coefficient, C, was found to be related to the Reynolds number of the fluid at the throat of the meter. Calibration of the other three tubes showed that for equal Reynolds numbers the coefficients for all four Venturis were the same within $\pm 2\%$. Accordingly, one calibration curve was drawn for all four.

In a discussion of an article by Ed S. Smith, Jr., F. N. Connet suggested[2] the use of the ratio of the friction loss across a Venturi metering element to the Venturi head, FH/VH, as a possible means of determining the flow of viscous liquids without the necessity of measuring the viscosity of the liquid. During the calibration of one of the Venturis the pressure drop from the entrance piezometer ring to the extreme end of the discharge side was measured and it was found that for all conditions of flow encountered during the calibration, the meter coefficient C was related to the ratio suggested by Connet.

It is realized that the data herein presented cover only a small range of viscosity and flow. They are presented with the hope that they will stimulate others to investigate the above-mentioned relationship over a wide range of flow.

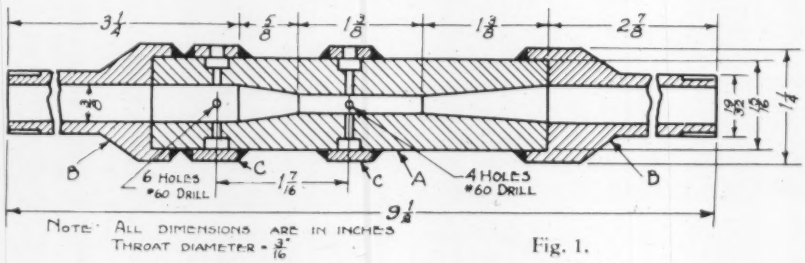

Fig. 1.

CONSTRUCTION OF VENTURIS

The Venturi tubes were constructed of steel, as nearly alike as possible. For ease in construction, each tube was made of five parts (Fig. 1): the main body A, the two ends B, and the two piezometer rings C. Parts A and B were carefully machined so that the inside joints between them offered a smooth uninterrupted passage for the fluid to be metered. At first all joints were soldered, but by reason of vibration transmitted from the engines to the Venturis through the connecting tubing, it became necessary later to braze the outside joints to prevent oil leakage.

CALIBRATION

The apparatus for calibrating the Venturis consisted of a positive displacement gear pump with a manually adjustable by-pass valve, a tank with a steam heating coil, and a weighing tank. The differential pressure between the throat and the entrance was measured with mercury manometers to the nearest 1/16". Since the Venturis were located on the discharge side of the circulating pump, precautions were taken to have the space above the mercury columns filled with oil and free from air. Corrections for the difference in head due to the oil above the mercury were made in the calculations. The temperature of the metered fluid was measured with a chromel-alumel thermocouple located 5 1/2" from the throat on the discharge side of the Venturi. The method of operation was as follows: Oil was circulated through the system until temperatures and flow were constant. The oil was then directed to the weighing tank. Since the change in direction of the flow of the oil made a slight change in the pressure drop across the Venturi as noted on the manometer, sufficient time was allowed for the mercury columns to become stabilized. The time required for 40 lbs. of the metered oil to accumulate in the weighing tank was measured with a stop watch.

The viscosity-temperature relationship of the oil used was determined with modified Ostwald pipettes, to an accuracy of $\pm 0.5\%$. The oil used had an A.P.I. gravity of 20.1 and viscosities at 100°F., 130°F., and 210°F. respectively of 575, 215, and 55.6 Saybolt seconds.

RESULTS

The discharge coefficients of the Venturis were calculated from

$$Q = CM \sqrt{2gh} \qquad (3)$$

where Q = actual discharge, ft.^{3}/sec.
C = discharge coefficient
$M = \dfrac{A_1}{\sqrt{r^4 - 1}}$
A_1 = area entrance section, sq. ft.
r = ratio of entrance to throat diameter
g = acceleration due to gravity
h = pressure drop between throat and entrance in feet of liquid flowing

Coefficients were plotted against Reynolds number $\left(\dfrac{DV\rho}{\mu}\right)$ at the throat of the Venturi (Fig. 2),

$$R = \frac{DV\rho}{\mu}$$

where D = throat diameter, ft.
V = actual throat velocity, ft./sec.
ρ = density, lbs./ft.^{3}
μ = absolute viscosity, lb./ft. sec. = poises $\times$ 0.0672

A calibration curve was desired that could be used easily and conveniently. The final calibration curve as

[1] Performance Tests of Lubricating Oils in Automobile Engines, H. A. Everett & F. C. Stewart, *Engineering Experiment Station Bulletin No. 44*, The Pennsylvania State College.

[2] The Oil Venturi Meter, *Transactions A.S.M.E.*, Vol. 45, 1923, pages 67-75.

[3] Fluid Meters, Part 1, Report of A.S.M.E. Special Research Committee on Fluid Meters.

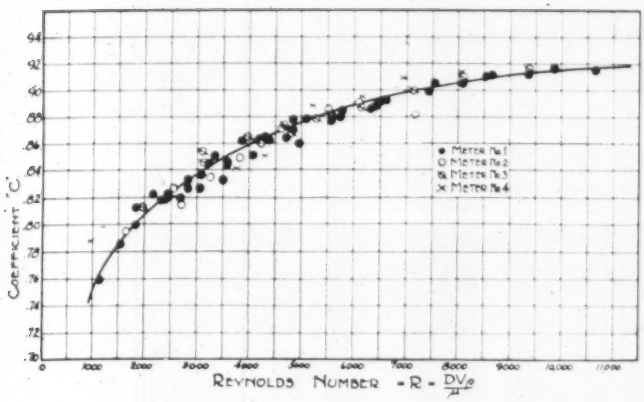

Fig. 2. Relation between coefficient C and Reynolds number at the throat of the meter. V is actual throat velocity.

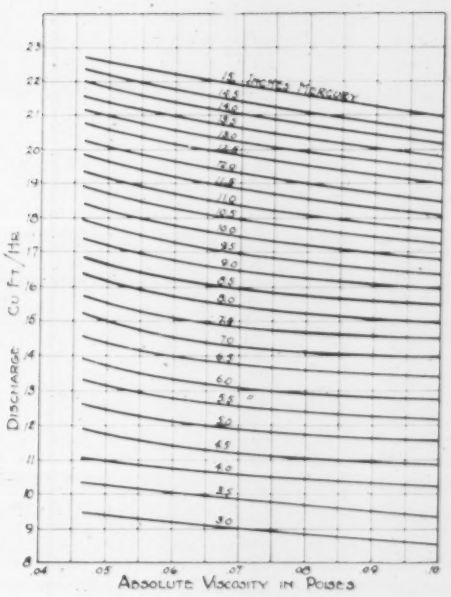

Fig. 3 Venturi calibration curves.

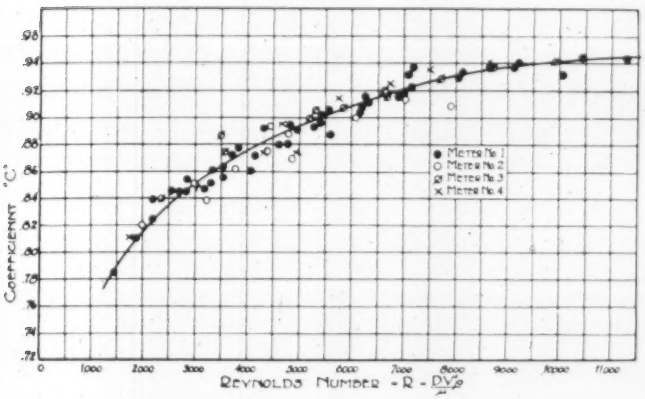

Fig. 4. Relation between C and $\frac{DV'\rho}{\mu}$ where V' is velocity obtained from $V' = \sqrt{2gh}$.

shown in Fig. 3 was arrived at by the following method: A series of Reynolds numbers were assumed. Assuming a series of six viscosities in the working range desired, the actual velocities through the throat for each viscosity were calculated from $V = \frac{R\mu}{D\rho}$. Knowing V, the quantity of oil, Q, was obtained from $Q = AV$. Then for each Q, knowing C, the pressure drop, h, across the Venturi was calculated from $Q = CM\sqrt{2gh}$. Curves of h against Q were then plotted for each of the assumed viscosities, thus resulting in six curves covering the range of viscosity desired, *i.e.*, the range used in calibrating the Venturis. From these curves, the final calibration curve, Fig. 3, of Q against μ with various pressure drops was obtained by cross-plotting.

The calibration curve, Fig. 3, covers the entire range of flow and viscosity that is likely to occur in the engine tests for which the metering element was designed. From dimensional considerations it is reasonable to expect that the relationship between C and $\frac{DV\rho}{\mu}$, Fig. 2, may be applied to any condition of flow in which the characteristics of the fluid are not too far removed from the fluid used in calibrating the meter. For example, the viscosity of the fluid may be 0.20 poises and the rate of flow such that the Reynolds number of the fluid at the throat falls within the range of Reynolds numbers obtained during calibration. Obviously, to use Fig. 2 for determining the Venturi coefficient C when only h and μ are known, it is necessary to resort to a trial-and-error method. To simplify the procedure of determining C under the above-mentioned conditions, the experimental coefficients were plotted against Reynolds numbers, giving Fig. 4 in which the velocity was calculated from

$$V' = \sqrt{2gh}$$

where h = pressure drop across the meter in feet of liquid flowing

Thus, knowing h and μ, it is only necessary to calculate $\frac{DV'\rho}{\mu}$, and determine the rate of flow from $Q = CAV'$.

The relation between the ratio of velocity head to the friction head, VH/FH, and Reynolds number at the throat is shown in Fig. 5. Fig. 6 shows the relationship between C and VH/FH; it covers rates of flow from approximately 8 to 30 ft.³/hr. and viscosities from 0.133 to 0.041 poises.

Figs. 5 and 6 are of particular interest because they indicate that a Venturi meter metering viscous liquids may act as its own viscosimeter, doing away with the necessity of temperature or viscosity measurements which are always more or less difficult or troublesome. Whether or not a relationship between VH/FH and R and C exists for all meters over a wide range of flow and viscosity is not known. Further investigation of this relationship is warranted.

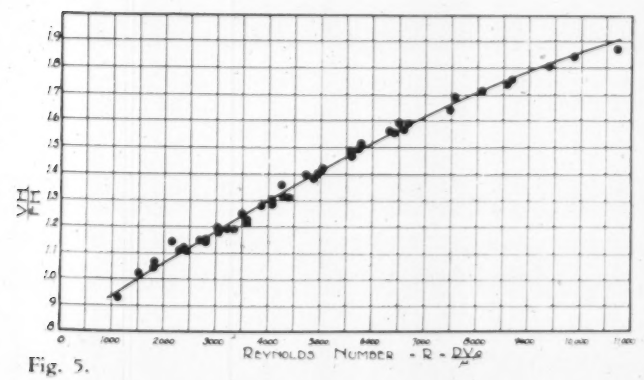

Fig. 5.

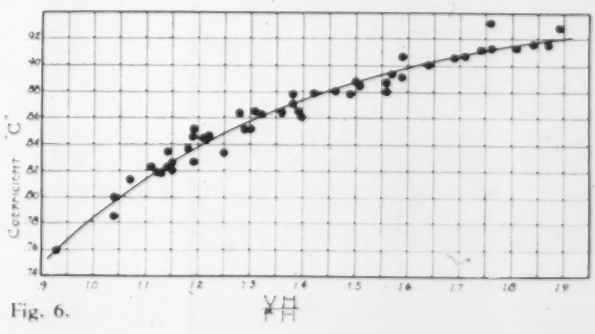

Fig. 6.

Rectifier Methods of Automatic Control of Alternator Voltage

By G. F. LAMPKIN
Lampkin Laboratories, Bradenton, Florida

THE compounding of direct current generators, wherein all or part of the load current is passed through series windings on the pole pieces, has long been followed as standard practice. By means of compounding, the terminal voltage can be made to remain essentially constant, to increase, or to decrease, as the load becomes larger. It is the purpose of this paper to describe means whereby similar control may be exercised on the terminal voltage of an alternator. The evolution as well as the finally devised means will be detailed, in order that a more complete and informative picture will be had.

The circuit diagram of Fig. 1 depicts a single-phase separately-excited alternator supplying a load circuit, and an arrangement in which a component dependent on the load current is taken out by means of series transformers. Although two separate transformers were readily available and were used as shown, a single transformer with split secondary winding would have been more desirable. The secondary voltages from the transformers are rectified by two tungar tubes and the resultant unidirectional product applied series aiding the field circuit. The curves show the performance of the system on a reactive load.

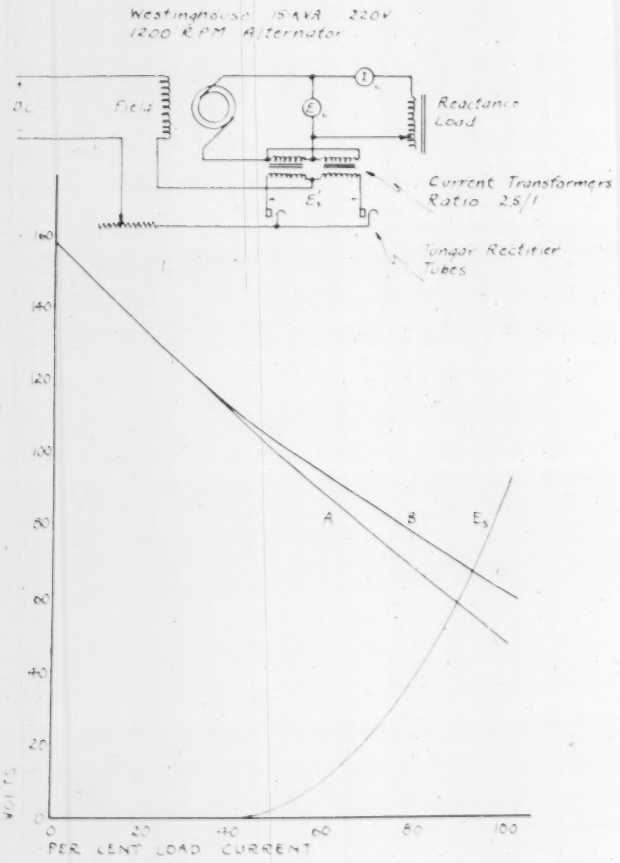

Fig. 1. Alternator Voltage Characteristics:
A—Without compounding
B—With compounding
E_s—Secondary voltage on series transformer

Curve *A* in Fig. 1 is drawn for comparison purposes, and is the voltage characteristic of the alternator without compounding. Curve *B* is the voltage across the same load with the compounding device cut in. The improvement in the regulation is not large; and, going into the reason therefor, the total voltage E_s across the series transformer secondaries is plotted, also, against load current. It is apparent that the voltage E_s is not developed immediately upon loading of the alternator, but that the line current must reach a definite value before compounding starts. This value is roughly determined by the current transformer ratio and the direct field current. The field circuit presents a shorted load to the series transformers until the peak rectified current exceeds the steady direct current. After this point is reached the line current tends to aid the field m.m.f. and compounding takes place. Some control over the threshold can be made through the ratio on the current transformer, but the system inherently is limited by the discontinuous characteristic.

A remedy is to provide the alternator with a tertiary field winding—analogous to the series field of a d-c. generator—and to supply it solely from the output of the rectifier. A circuit setup embodying this principle is drawn in Fig. 2. The ampere-turns requisite for the tertiary field winding usually are best obtained with a relatively small rectified current, in order that reasonable efficiency may result in the rectifier.

The data for the curves of Fig. 2 were measured on a Triumph 5-kw. 125-V. 1800-r.p.m. single-phase alternator. On the machine an auxiliary field winding similar

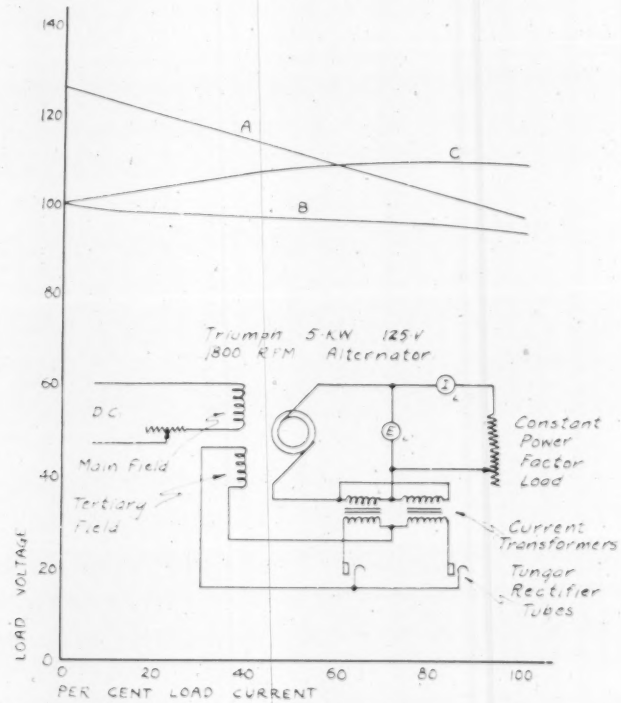

Fig. 2. Alternator Voltage Characteristics:
A—Without compounding
B—With compounding, transformer ratio 20/1.
C—With compounding, transformer ratio 10/1.

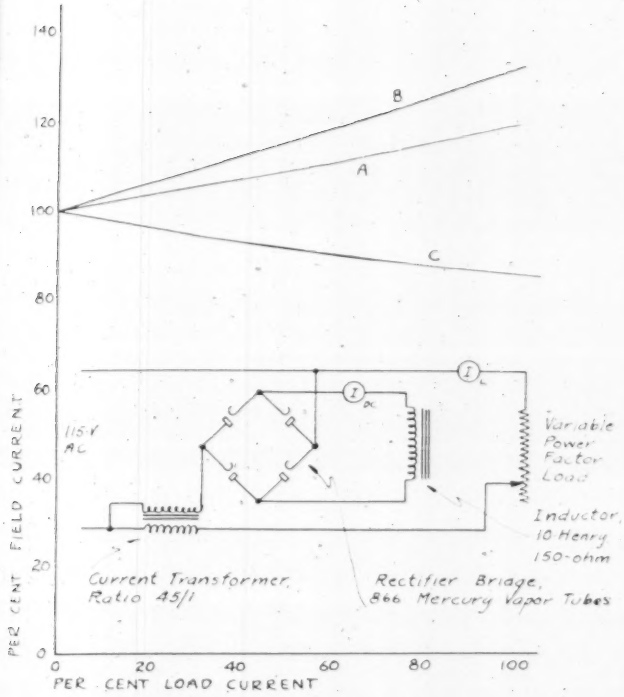

Fig. 3. Field Characteristics from Static Set-up:
A—Load power factor = 1.0
B—Load power factor = 0.8 lagging
C—Load power factor = 0.5 leading

to the main field was available, and it was excited with the rectifier output. Curve *A* was taken without compounding and shows a regulation of 30%. Curve *B* was run with compounding using a ratio of 20/1 on each series transformer. The voltage is practically constant over the major portion of the load range, the departures occurring to a slight degree only at the end points. The total voltage change from full to no load is 6%. When the ratio on the transformers was made 10/1, the curve C resulted; on this the load voltage goes up as the load increases, and the regulation figures to be 10%.

This method of control automatically will hold alternator voltage within any practical limits desired, provided that the load is of constant or nearly constant power factor. The qualification is necessary, since the compounding action depends only on the value, and not the phase, of the line current.

The final evolution tends to correct the effects of both parameters, and a circuit is illustrated in the diagram of Fig. 3. The test setup was made with static apparatus, but it may be noted that rigorous similarity exists as compared with the alternator, assuming constant terminal voltage is attained. The entire field m.m.f. is created through the medium of a rectifier. Part of the supply voltage for the rectifier comes in shunt from the alternator terminals, and the remainder is taken from the line current by means of the series transformer. The e.m.f.'s derived from the shunt and series elements add vectorially, and their resultant determines the total rectified field current.

The curves in Fig. 3 show the results of a run on the static setup. The data are presented in the form of field characteristics, showing the relation between field, or rectified current and the armature or line current, for three different values of power factor on the load. The typical characteristics, necessary for constant alternator voltage at different power factors and varying loads, are closely followed. For any particular application, the voltages from the shunt and series elements, and their relative phases, may be properly proportioned so as to yield the desired result.

The method outlined in Fig. 3 results in an economy of apparatus, in that neither a separate exciter nor a field commutator is necessary. The sole field supply comes through the rectifier, and, with the provision of a small battery to light the rectifier filaments for starting only, the alternator unit may be made self-sufficient. The method of Fig. 3 has distinct advantages when applied to alternator design, and permits improved performance especially in small or isolated plants.

Intended Substitution of the Practical Absolute System of Electrical Units for the Existing International System

The following information, released by the International Committee of Weights and Measures at its meeting in October, 1935, at Sèvres, France, has been communicated to *Instruments* by Professor A. E. Kennelly, American Member.

(1) In accordance with the authority and responsibility placed upon it by the General Conference of Weight and Measures in 1933, the International Committee of Weights and Measures has decided that the actual substitution of the absolute system of electrical units for the international system shall take place on the 1st January, 1940.

(2) In collaboration with the national physical laboratories, the Committee is actively engaged in establishing the ratios between the international units and the corresponding practical absolute units.

(3) The Committee directs attention to the fact that it is not at all necessary for any existing electrical standard to be altered or modified with a view to making its actual value conform with the new units. For the majority of engineering applications the old values of the international standards will be sufficiently close to the new for no change, even of a numerical nature, to be required. If for any special reason a higher precision is necessary, numerical corrections can always be applied.

(4) The following table gives a provisional list of the ratios of the international units to the corresponding practical absolute units, taken to the fourth decimal place. Since differences affecting the fifth decimal place exist between the standards of the international units held by the various national laboratories and also because all the laboratories which have undertaken determinations of the values of their standards in absolute measure have not yet obtained final results, the Committee does not consider it desirable for the present to seek a higher precision. At the same time it hopes that it will be possible to extend the table of these ratios with a close approximation to the fifth decimal place well before the date fixed for the actual substitution of the practical absolute system for the international system.

1 Ampere International	=	0.999 9	Ampere Absolute
1 Coulomb	"	=	0.999 9	Coulomb "
1 Ohm	"	=	1.000 5	Ohm "
1 Volt	"	=	1.000 4	Volt "
1 Henry	"	=	1.000 5	Henry "
1 Farad	"	=	0.999 5	Farad "
1 Weber	"	=	1.000 4	Weber "
1 Watt	"	=	1.000 3	Watt "
1 Joule	"	=	1.000 3	Joule "

Auxiliary Equipment for Cathode-ray Tubes

Seventh part of "The Cathode-ray Oscillograph and Its Applications" being published serially in *Instruments*. This series began in the July 1935 issue.

By RALPH R. BATCHER

Radio engineer; cathode-ray and electronic application specialist, Hollis, L. I., N. Y.

The character and amount of equipment[1,2,3,4,5,6] associated with a cathode-ray tube depend upon whether the complete oscillograph is required for general laboratory and development work or as a specific test set-up for a definite job. A power supply to furnish the necessary operating voltages may be all that is required in many cases; for other tests a time base oscillator (sometimes referred to as a "sweep circuit") or a deflection amplifier and, in some cases, a recording camera. These items comprise the most useful auxiliary items and will be described in detail.

In recent issues of *Instruments* several commercial oscillographs have been described and advertised. These show the recent trend: to provide a complete unit for general purpose testing, including self-contained amplifiers connected to the deflection plates, a linear time base oscillator and a power supply. It usually is uneconomical for the testing engineers in an industrial organization to assemble their own basic units and equipment. On the other hand these units have been for the most part designed with electrical laboratory and radio testing problems in mind, and the peculiar requirements in other industrial lines may require revision or alteration of the circuits. It therefore will be the purpose of this and the next two articles to describe both the basic circuits involved with data for specific designs which may be made up from common electrical parts, and also to discuss the circuits and facilities provided in commercial outfits.

In nearly all makes of apparatus the power supply circuits are basically identical, but considerable variations are found in the time base portion of the equipment, and in the deflection amplifiers.

POWER UNITS

The power supply is the one essential piece of apparatus required for any test with a cathode-ray tube. Since the advent of low-voltage tubes with heated cathodes, this problem is by no means as formidable as formerly when potentials of the order of ten kilovolts were required. Since the actual power used is small, the design of a power unit calls mainly for adequate insulation and accurate controls.

Since the usual cathode ray tube filament requires several amperes at a potential of one to three volts, the usual six-volt storage battery is not convenient or desirable as there is always a chance of a misadjustment that may destroy the filament. In nearly all modern tubes the filament is designed so that a-c. heating is applicable.

A half wave rectifier circuit will usually suffice as a power supply, if it is not called upon to furnish the necessary potentials for a time base oscillator and amplifiers in addition, as in Fig. 1a. In this same diagram two other circuits are included; Fig. 1b, a full-wave rectifier and 1c a "voltage doubler" circuit. It has been common practice to use an 81 rectifier tube for potentials of the order of one kilovolt which are needed for the anode circuit, or an 866 tube for potentials up to three kilovolts. These voltages are greater than rated values

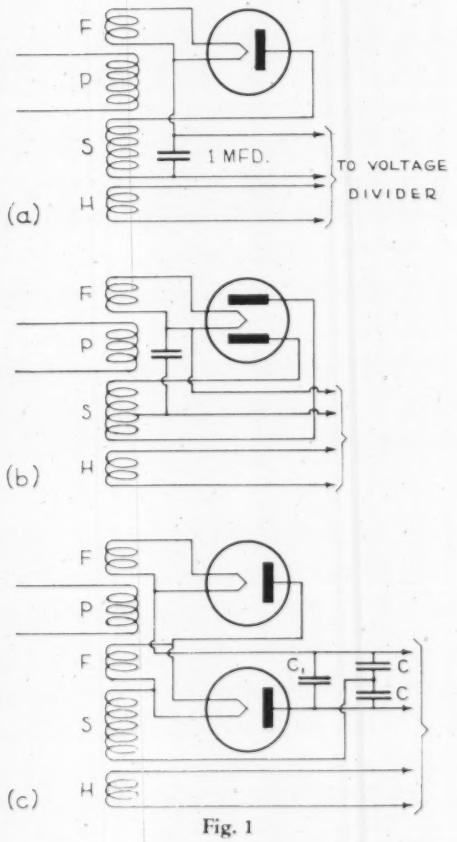

Fig. 1

but due to the small current drain the tubes have been able to give good service. However the types 878 and 879 rectifier tubes have been designed for this service and their use is preferred.

There are two full-wave rectifier circuits commonly used, as illustrated in Fig. 1b and 1c. In the former either a double anode (full-wave) rectifier tube or two half-wave tubes may be used. This circuit requires a transformer with a tapped secondary, each half of which has a voltage somewhat less than the required d-c. voltage. In the latter circuit (1c) two separate half-wave tubes are required, operated from different filament windings. The transformer secondary should have a voltage about 40% (RMS) that of the required d-c. voltage.

The capacity of the series condensers across the output affects the output potential to a considerable degree. If these condensers have a capacity of about 1 mfd each and C_1 is $\frac{1}{2}$ mfd. the output voltage will be more than twice the RMS value of the secondary voltage.

The output circuit should be shunted with a high resistance (not shown) to discharge the condensers after the tube is disconnected. The cathode will ordinarily

(Note: A large number of application references to cathode-ray oscillographs are found in technical publications, which also give certain details of associated apparatus. These will be listed in the final Bibliography.)

[1] John Rider. The Cathode-Ray Tube at Work. Rider Publishing Co., New York, 1935.

[2] Watson Watt. The Cathode-Ray Oscillograph in Radio Research. H.M.S. Stationery Office, London, 1933.

[3] Crawford. Some Improvements in Cathode-ray Oscillographs. *General Radio Experimenter*, Vol. 8, 1933, No. 1-2.

[4] Meier & Richards. Power Supply and Linear Time Axis. *Electronics*, Vol. 7, 1934, pages 110-112.

[5] Ghirardi. Modern Radio Servicing. Radio & Technical Publishing Co., New York, 1935.

[6] Terman. Measurements in Radio Engineering. McGraw-Hill Book Co., New York, 1935.

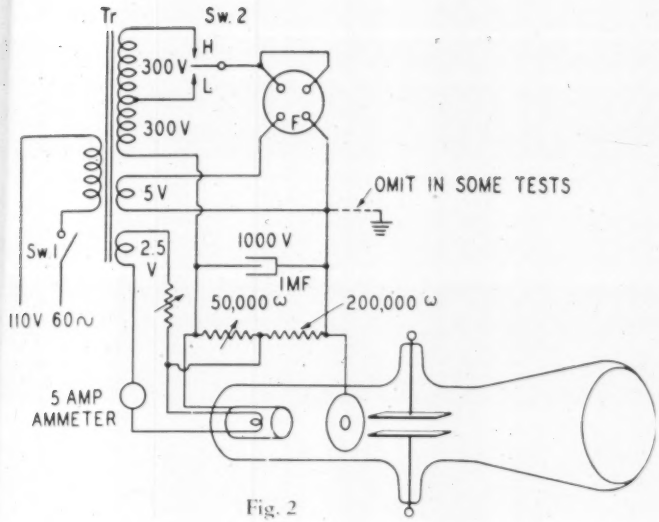

Fig. 2

cool off before the output condensers are fully discharged, leaving certain parts of the circuit "live." The usual voltage divider circuit used for focusing will provide this leak. The leads extending from the Fig. 1 diagrams connect to the voltage divider circuits as in Fig. 3 which will be described later.

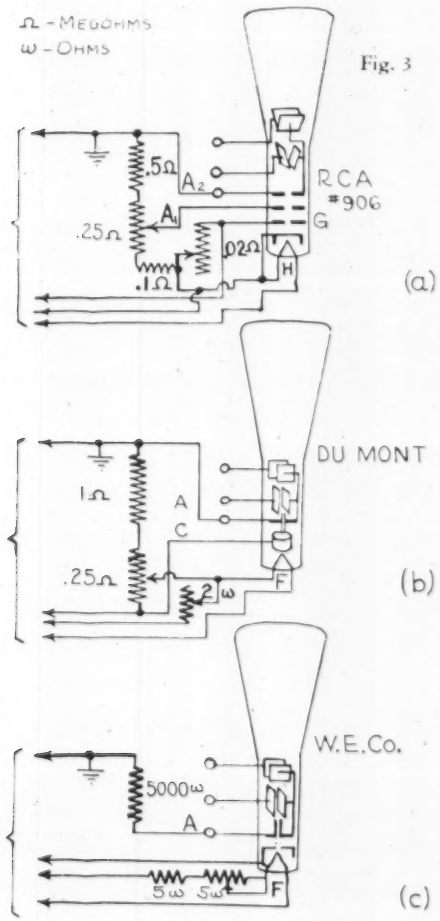

Fig. 3

TRANSFORMERS

The main requirements for the transformer is to supply the filament voltage for the cathode-ray tube, the rectifier filament and the high-voltage winding. A number of other features are sometimes useful which will require additional secondary windings. These will be taken up in another section.

Experience indicates that more than usual insulation is needed between the high voltage windings and the other windings. It is desirable to have two layers of paper between the layers of the secondary winding. With the secondary open and with rated voltage applied to primary, no spark should be noticeable if the end of the high voltage winding farthest away from the primary is touched to one of the primary terminals. An electrostatic shield outside the primary is desirable.

It will be found that a transformer of a type used in radio receiving sets will sometimes suffice for use in a power supply. If the secondary has a voltage of approx. 750 volts (the center tap is not needed), a 2.5 volt winding and a winding for the rectifier tube filament, most of the recent types of cathode ray tubes can be operated therefrom at an anode level of 1000 volts. It is necessary that such a transformer be checked with an insulation breakdown test, to insure that the insulation between windings is adequate. Fig. 2 shows this circuit, adapted for the gas focus type of cathode ray tube.[3]

In Fig. 3 several circuits are shown by which the operating potentials are obtained for several makes of tubes now available. These data will be supplemented by additional information in a separate article devoted to a résumé of present day tube characteristics, socket connections and recommended circuits, taken from the manufacturers' data. In the design of the voltage dividers used with the circuits, Fig. 3, it usually is sufficiently accurate to provide a total resistance of about one meg ohm per kilovolt anode potential and to disregard the actual load due to the tube itself when figuring where the taps should come out. These circuits are to be used

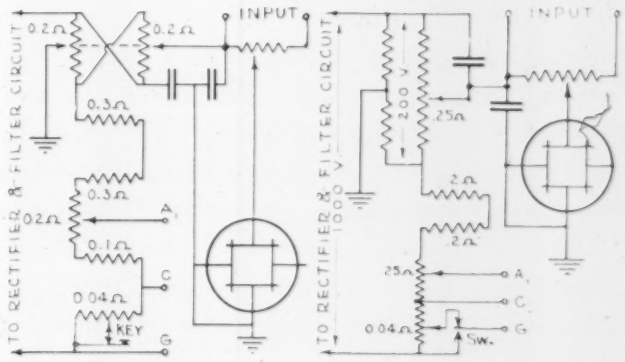

Fig. 4

in conjunction with one of the rectifier circuits of Fig. 1 (usually 1a). Additional voltage divider circuits, with position and amplitude control features added are shown in Fig. 4.

In Fig. 4a, a two-section potentiometer (two resistance sections operated by the same shaft) is used. A single element unit can be used however, as in Fig. 4b, but there is a permanent potential loss in the anode circuit with this method. In each diagram, Fig. 3 or 4, the leads A_1, C and G refer to the focusing electrode, cathode and modulating electrode of the RCA 906 tube. Slight revisions may be required for other tubes.

Manufacturers' data usually include a warning against letting the spot remain stationary for any length of time, on account of screen disintegration. It seems that in many cases the designers are unusually pessimistic as to how much punishment the screen will take, but nevertheless it is easy to extinguish the spot during

[3] Batcher, How to Use Cathode-Ray Tubes, *Modern Radio*, Vol. 1, August 1932, pages 19-21.

intervals when the tube is not being viewed, without turning off the filament. When a modulation electrode is present a simple key (Fig. 4a) or switch (Fig. 4b) can be added to increase the cut-off bias to this electrode, as shown. An alternative method is to tape two small

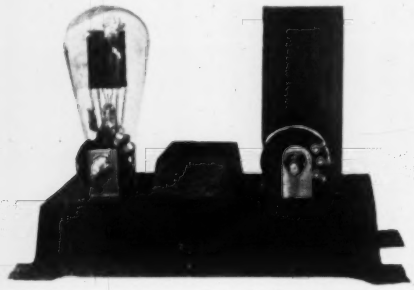

Fig. 5

deflection coils to the tube and to apply either an a-c. wave to them so as to rotate the spot over some sort of elliptical pattern or else to use a battery to deflect the spot to the extreme edge of the screen.

A power supply "chassis" containing the necessary parts mounted in a cast iron shield is shown in Fig. 5.

MOUNTING THE TUBE

Approximately two feet separation between power transformer and cathode-ray tube is usually required to reduce the effect of the transformer field upon the ray. When that portion of the cathode-ray tube that encloses the anode and cathode is surrounded with a steel tube, the distance can be reduced. The effect of the stray field is to transform the spot into an irregular line or an ellipse.

If the space available in the equipment is limited, a little experimenting while locating the power transformer will usually disclose a position where the stray field has the least effect on the electron stream. A practical test is to connect up the circuit with long flexible

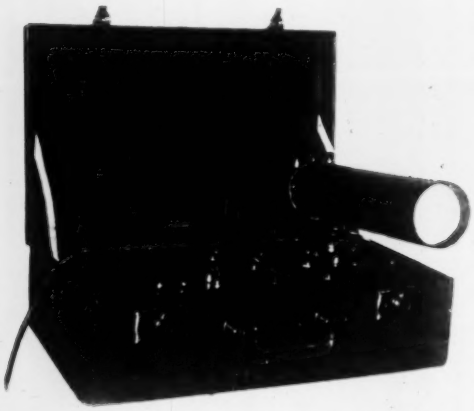

Fig. 6

leads to the power transformer, and to rotate the latter until the spot on the screen is a "dot," *i.e.* not a "*line*." If the stray field from the transformer is kept below the mounting socket for the tube, little distortion is found under normal conditions. This can be done by mounting the transformer in line with the axis of the tube below its base. When it is necessary to mount the tube closer to the power transformer it is essential that the tube be mounted in a magnetic shield. A mounting stand is shown in Fig. 6 where a steel cylinder is slipped over the tube, providing an electrostatic shield and some additional protection against magnetic fields as well.* A third advantage is that it darkens the screen so that the oscillogram is visible in daylight.

For magnetic deflection coils the steel tube is replaced by one of Bakelite in which the deflection coils are permanently located. This type of mounting stand was illustrated in Fig. 5 in the September 1935 article.

For many tests, especially with high-frequency circuits, it is desirable to separate the leads of the deflection plates from the same cable with the rest. Separate leads should be provided, or even better, place the deflection plate binding posts on the mounting stand near the socket. This feature has been incorporated in the apparatus shown in Fig. 6. The viewing angle can be varied to suit personal convenience here.

RATIO TRANSFORMERS

A voltage transformer with a high step-up ratio provides a simple method of increasing the electrostatic sensitivity for frequencies within the audio range. This arrangement can be used to convert small *IR* drops (current values) into potentials suitable for electrostatic deflection and is at times an inexpensive substitute for deflection coils.

Turn ratios as high as 100 to 1 have been used for this purpose, and there is no reason why even higher ratios cannot be used. The primary (of relatively low impedance) can be connected directly into the circuit, and the secondary connected to the deflection plates.

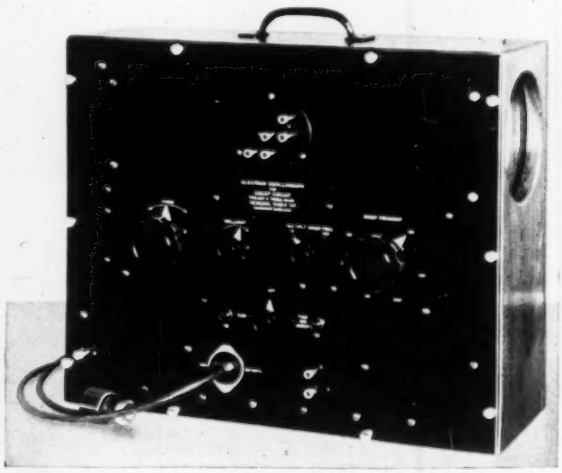

Fig. 7

In order that the primary shall present a definite impedance to the circuit, the secondary should be shunted with a resistance load. This load can take the form of a three-terminal voltage divider, wherein the adjustable element can be used to control the deflection amplitude. This resistance load has also the effect of keeping the flux density lower so as to reduce the possibility of introducing harmonics which would affect the accuracy of the tests.

*A steel tube of the Shelby type about one-sixteenth of an inch thick makes an excellent magnetic shield, but it often becomes magnetized itself, as the retentivity of the metal is rather high. A tube made of a few turns of thin high-silicon transformer steel or better yet "high-mu" or "A" metal has better characteristic in this matter. Several turns of this strip having a width equal to the desired length of tube are wound around a mandrel and held with tape into the cylindrical shape.

The General Radio Company has pioneered in the production of complete cathode ray units. Fig. 7 shows one of their current models.[7]

The general utility oscillograph illustrated in Fig. 8 (RCA type TMV 122 B) is an example of another arrangement.[8] This outfit utilizes the circuit of Fig. 9.* In

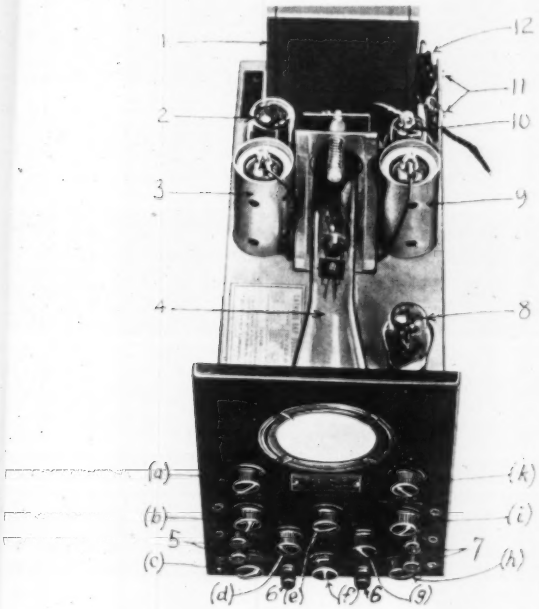

Fig. 8

order to facilitate the study of this diagram, the power supply circuit is shown with heavy lines, wherever they can be segregated; the deflection amplifiers (one is supplied to each set of deflection plates) are shown in light lines; and the timing wave oscillator by dotted lines. The power supply consists of two rectifier systems (2) and (10) Fig. 8, in series. The cathode-ray tube anode voltage is provided by the 879 tube, while the amplifiers and the time base circuits are supplied by the 80 tube. Since it is usually desirable to operate the cathode ray tube with the anode grounded, the positive side of the high-voltage supply is connected to the negative side of the low voltage supply. The variable resistors that control the focus (*k*) and intensity (*a*) (brilliance) are

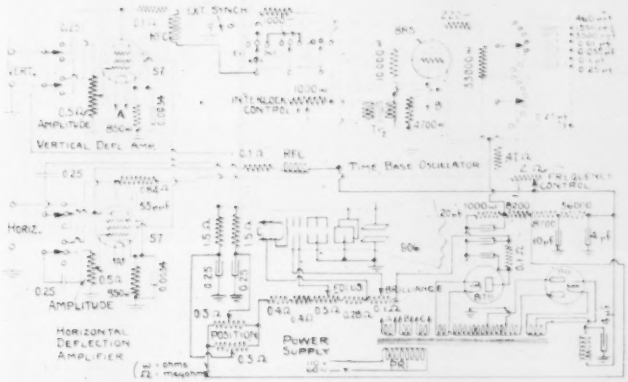

Fig. 9

similarly placed to those in Fig. 3. (Notations refer to Fig. 8.) Two position controls (11) are provided which insert a steady potential in each deflection plate circuit which shift the diagram in any direction as desired. Each amplifier consists of a single stage using a 57 tube as shown, in a conventional circuit. Switching is provided (*b*) and (*i*) to disconnect either amplifier if not needed, and in the case of the horizontal deflection amplifier to connect it to the output of the timing base oscillator. Before discussing details of the latter circuit, general considerations of these oscillators will be taken up.

To be continued.

*Minor changes seem to have been frequently made in this circuit (as for example in the frequency range control switch) but the circuit shown is a late model.

[7] H.M.S. Stationery Office, London, 1933.
[8] *Instruments*, Vol. 8, August 1935, page 243.
[9] *Instruments*, Vol. 8, May 1935, page 135.

INSTRUMENTS' BOOK SHELF

Measuring Practice (Technisches Messen). VDI Verlag, G.m.b.H. Berlin, 1934. Paper, 5¾x8¼ inches, 32 pages. Price 1.50 RM.

This is the tenth booklet published by the Verein deutscher Ingenieure. It is intended that this book give the German engineer the expressions used in this field of engineering. The booklet is printed in English and has 31 illustrations with captions and annotations, thus providing the reader with a vocabulary in this branch of engineering. A dictionary of 400 words is included. RICHARD RIMBACH (1.2)-B-

Mercury Arc Rectifier Practice. By F. C. ORCHARD. Chapman & Hall, Ltd., London, 1935. Cloth, 5½x8¼ inches, 224 pages. Price 15s.

This book is intended to bridge the gap between the many publications in this field which limit themselves to descriptions and brief statement of elementary principles, and those which go quite completely into the mathematical and physical theories involved. It should then be very useful to the plant engineer and operator, and should enable him to consider a rectifier layout more intelligently and to carry on maintenance and overcome troubles more efficiently and successfully.

The book is quite successful in accomplishing its purpose. The explanatory matter is adequate, and all practical aspects are sufficiently treated. The many good pictorial illustrations, as well as charts and performance curves of actual installations, add to the book's value. J. SLEPIAN (5.4)-B-

Chemical Engineering Catalog, 20th Edition. Reinhold Publishing Corporation, New York, 1935. Cloth, 8½x11¼ inches, 863 pages. Price $10.00, except to special classes of technical men to whom it is lent gratis or sold for $3.00.

A gay orange and blue binding distinguishes the latest edition, but its contents are classified as in preceding years: Plant equipment, chemicals and raw materials, technical books, and a helpful list of trade names. A new departure is the separation of the index of chemicals and raw materials into two sections: (1) industrial chemicals and raw materials, and (2) laboratory and reagent chemicals, the second list referring to those firms who can supply chemicals in units of 25 lbs. or less. these two sections have been carefully cross-indexed.

An increase of more than 100 pages over the previous edition brings that much more information to the plant manager's desk, and is an encouraging sign that better times are here.

M. L. MOORMAN (12)-B-

Materials Testing—Theory and Practice. By IRVING H. COWDREY and RALPH G. ADAMS. John Wiley & Sons, New York. Second edition, 1935. Cloth, 6⅞ x 9¼ inches, 144 pages. Price $1.75.

In this little book the authors accomplish just what they set out to do, which was to provide a textbook for beginning students. They have described, briefly and simply, the fundamentals of mechanical testing. It is not a book for advanced students nor for the engineer with special problems in the testing of materials. It is somewhat elementary to serve as a text for students of metallurgy. In general the selection of material has been excellent. In the opinion of the reviewer, a little space should have been devoted to endurance tests, both creep and fatigue, which have not been treated.

M. GENSAMER (3.1) -B-

No. 1

CLARKE E. FRY
of Westinghouse

By M. F. BEHAR

SERVING several Westinghouse plants in the Pittsburgh district (including the Micarta works and the foundry at Trafford, the Linhart plant and copper mill, the Nuttall works, the Derry ceramic plant, as well as the three-mile-long "E & M" works at East Pittsburgh) is a central Instrument Laboratory. C. E. Fry heads it. His twenty specially-trained calibrators perform (*a*) acceptance tests, (*b*) periodic calibrations and (*c*) repairs, as he outlined in our August 1930 issue, pages 485-488. For thousands of instruments (such as mercury-in-glass thermometers, etc.) the rigid acceptance test ends the department's responsibility; it is only the beginning for Standards and other important instruments already numbering 2097 (see list).

The Westinghouse policy being to look ahead at the savings effected by excellent instruments rather than to "save on first cost and trust to luck," one is not surprised to see precision equipment of the highest grade.

Calibrations are usually made at not less than seven fiducial points. Noteworthy are the transformers—certified by the National Bureau of Standards—whereby ratio tests are accurate to 0.1% and phase angle tests to 5 minutes. Inasmuch as Westinghouse manufactures electrical instruments and meters at its Newark, (N. J.) works, many switchboard instruments and meters in the power plants do not first pass through Mr. Fry's department but are sent there for periodic calibrations. Those of other makes, however, go through acceptance tests.

The above mention of instruments "merely" put through acceptance tests must be qualified with respect to hundreds (if not thousands) of devices used in the many production test and inspection departments around East Pittsburgh, on which Mr. Fry's men "keep an eye." Examples: complete test tables, manometer boards, oscillographs, turn counters and comparators, resistance bridges, dynamometers, magnetic test outfits, and other assembled *equipments* each including on its panel board a plurality of indicators.

Likewise with automatic control systems: such elements as air compressors, motors, contactors, valves, air filters, etc., are serviced by maintenance men in other departments, but most of the "instrument-like" parts (including even the rubber diaphragms of control valves) are adjusted or repaired by Mr. Fry's men. Likewise, too, with hundreds of recorders (recording flow meters, for example): their thermal tube-systems, high-pressure elements and other such parts are sent to the original manufacturers, but clocks, diaphragms, etc., go to the Laboratory.

THE 2097 IMPORTANT INSTRUMENTS

A-c. ammeters	213
D-c. ammeters	155
A-c. voltmeters	186
D-c. voltmeters	214
D-c. millivoltmeters	150
D-c. shunts	208
Thermal ammeters	5
Wattmeters	96
Frequency meters	12
Electrostatic voltmeters	2
Averaging voltmeters	2
Iron loss voltmeter	1
Crest voltmeters	4
Power factor meters	2
Dudell Mather wattmeter	1
Meggers	4
Special output meters	2
Microfaradmeters	9
Power factor & capacitance bridge	1
Resistance bridges	14
Potentiometers	21
Telephone interference factor meters	2
Cycle counters (dial type)	4
Commutator roughness factor meter	1
Electromagnetic oscillographs	4
Thermoelectric pyrometers	248
Optical pyrometer	1
Recording thermometers	347
Special thermostats	80
Electrothermal anemometers	9
Mechanical anemometers	3
Electrical tachometers	85
Mechanical tachometers	10
Foot-candle meter	1

In addition to supervising these departmental functions, Mr. Fry's responsibilities include (*a*) consultation on instrument purchases and proper applications and (*b*) designing special instruments when none on the market possesses the required characteristics. Among the hundreds of important automatic-control applications around Pittsburgh are cyanide and lead baths, solder pots, heat-treating furnaces for expensive tools, and the world's largest coil impregnating tank. Among the special instruments which Mr. Fry assisted in designing are a thermal type air current meter, coil-turn comparators and an automatic tester for "Rectox" washers.

Truly a man-size job! Now examine the photograph taken a few days ago: young as he looks, Mr. Fry is now celebrating a quarter-century of service to Westinghouse, the last twenty years as head of the Instrument Laboratory!

Mr. Fry has been an *Instruments* subscriber for eight years—since Vol. I, No. 1 came out—and has a complete file.

Telemetering and Totalizing*

By PERRY A. BORDEN and M. F. BEHAR
Member A.I.E.E. Editor, *Instruments*

Continued

9. Impulse Class

(a) General Characteristics.

The transmission of measurements by the use of timed electrical impulses finds many and varied applications; and in the past few years there have appeared a large number and variety of impulse systems of telemetering. Actually, the transmitted variable in an impulse system of telemetering is a *time interval*, the electric current or voltage merely serving as a medium through which the individual impulses are defined. This makes impulse systems particularly suited to long lines subject to disturbing conditions, as the electrical value or "strength" and nature of an impulse may be changed to suit conditions, and the impulse carried through protective, amplifying, or insulating units without loss of accuracy of measurement.

Impulse systems can readily be used, therefore, on communication circuits, the voice currents being practically undisturbed by the impulses—which at worst need be no more than a series of slight clicks.

In order to avoid possible misunderstanding, it may here be observed that the term "impulse," as used in this discussion, refers to the time interval between successive changes in an electrical magnitude, rather than to an actual change; thus the impulse is considered as having a measurable duration, and cannot be represented by an instant of time.

Where impulses are all of the same nature, the interconnecting circuit need have but two conductors, the transmitting element taking the form of a simple make-and-break contact. Where alternate polarities are used, there must be either a source of power available at the transmitting instrument, or else resort must be had to a three-conductor circuit, in which case ground may sometimes be used as one conductor.

Impulse systems of telemetering may be divided into four more or less distinct types, each requiring special equipment and having its special applications. These types are as follows:

(1) *Impulse-counting*, in which the transmitting line is caused to carry a series of electrical impulses, generally governed by a contacting device associated with the primary measuring element, these being counted by the receiving instrument and translated into readable values without regard to the frequency of their occurrence.

(2) *Impulse-frequency*, in which impulses controlled by the transmitting unit are produced at a frequency proportional to the measured value, and actuate a receiving instrument whose response depends upon this frequency.

(3) *Impulse-spacing*, in which the line carries two sets of impulses which may or may not be of a similar nature, one set occurring at uniform intervals and the other governed by the primary measuring element, being timed in relation to the first.

(4) *Impulse-duration*, in which the line carries a series of impulses, uniformly timed as regards successive occurrence, but of durations varying with the measured magnitude. In some of these systems the beginnings of successive impulses are evenly timed, and their endings varied with the measured magnitude (or vice versa) while in others the middle points of the impulses are evenly timed, the transmitter mechanism serving to extend or decrease their durations by varying both the instant of beginning and the instant of ending.

*Sixteenth chapter (XLIV) of Part Seven (Handbook of Industrial Electrical Measurements and Control) of Béhar's *Manual of Instrumentation*. See editorial announcement of this series on page A7 of November 1933 *Instruments*. Each chapter is subjected to a final revision shortly before its appearance in this serial form, in order to assure that the subject matter is thoroughly up to date. This new book is not published serially in any other periodical. Entire contents copyright.

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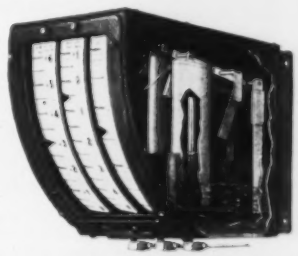

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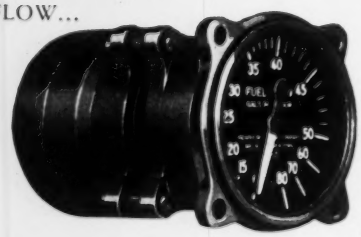

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The general nature of these four types will be better understood by reference to Fig. 44-55; and it will be seen how flexibility may be obtained, and a further classification into sub-types produced, by using direct-current impulses of alternate polarities, or by identifying particular impulses in a series by a predetermined duration differing from others, or by the use of alternating-current and direct-current impulses in the one circuit.

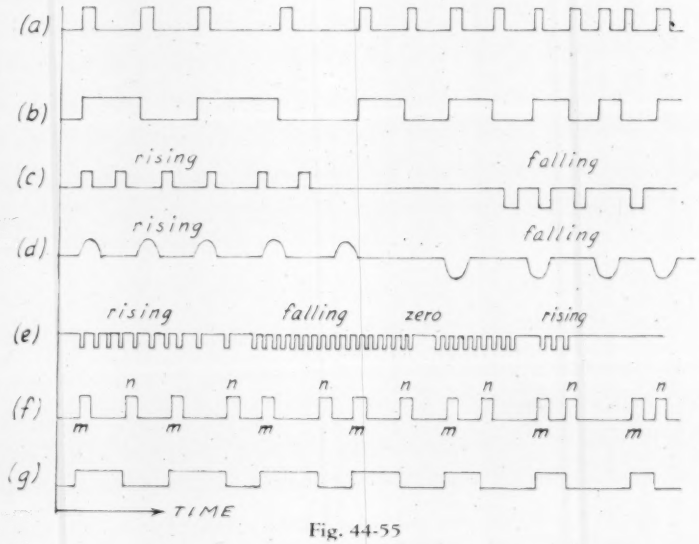

Fig. 44-55

(a) and (b) Impulse-counting and impulse-frequency systems. The measured magnitude is represented by the frequency of occurrence of the short impulses in (a) or of the reversals in (b).

(c) and (d) Impulse-counting system in which deflections in opposite directions are represented by corresponding polarities of impulses. Impulses originating in an interrupter, as in the Meyer Relay Telemeter, are shown at (c), and those from an intermittent magneto, as in the Ericsson system, at (d).

(e) Impulses of the Kennedy system, in which an increasing value is represented by impulses spaced in accordance with the speed of increase, and a decreasing value by a complete cycle of rapidly recurring impulses carrying the indicator completely around the scale to the new low value, with a pause at zero.

(f) Impulse-spacing system. The impulses n_1, n_2, n_3, . . . occur at uniform time intervals, and provide a zero of reference for each cycle. The impulses m_1, m_2, m_3, . . . are spaced from the isochronous impulses by time intervals corresponding to the respective values of the measured magnitude.

(g) Impulse-duration system. The beginnings of impulses are isochronous, and their terminations vary with the measured magnitude, so that the duration of each impulse represents the then value of the magnitude under measurement.

(b) Impulse-counting Type.

Impulse-counting systems are particularly suited for transmitting a slowly changing indication (as of liquid-level) or a continually progressing integration, i.e., the registration of a meter — which of course consists of counting. The transmitting section usually embodies a contactor which controls impulses of the same or different polarities, the receiving instrument responding to these individually without regard to the frequency of their occurrence.

Meyer Relay Telemeter.

A commercial example of this type, particularly designed for transmitting measurements of flow or of liquid level, is the Relay Telemeter, supplied by the Meyer Instrument Co. The transmitting unit is actuated by a float which operates a cam arranged to make a definite number of electrical contacts in proportion to the rising movement of the float. Each impulse actuates the pen of a recorder in the receiving section, so that the record takes the form of a definite count of the impulses transmitted. A time-delay relay clears the circuit shortly after the beginning of each impulse, so that if the cam stops with the contacts in a closed position the current is not left flowing in the line. A "reverse breaker" attached to the cam shaft acts to open the circuit when the float begins to recede, so that indications are made in one direction only, i.e., with rising liquid level in the tank or reservoir. This device is supplied in a

single-pen type and also in a double-pen type for rapid changes. The receiving instrument may be in the form of a multiple-pen recorder, and thus provide on a single chart records from a number of independent transmitters. Integra-

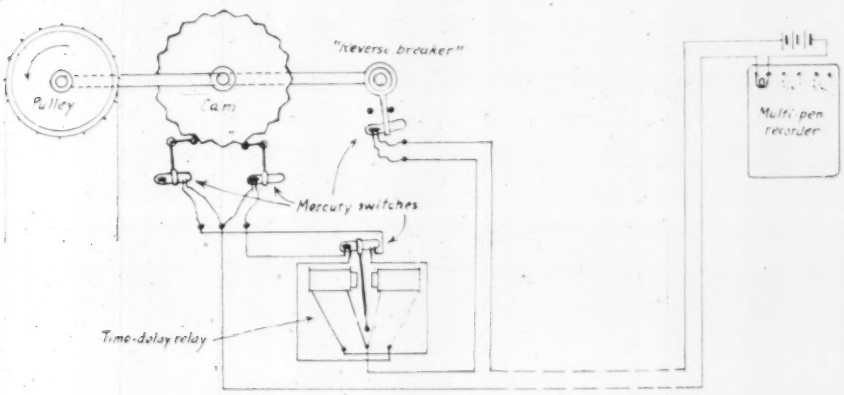

Fig. 44-56

tion is accomplished by the simple expedient of adding an electromagnetic counter to the receiving instrument. The basic diagram of the system is shown in Fig. 44-56, and the general nature of the impulses is as shown at (*a*) in Fig. 44-55, which would also be the type of record obtained on the receiving instrument.

Stevens Remote-Registering System.

In the Stevens impulse systems of telemetering, produced by Leupold Volpel & Co., impulses depending in polarity upon the direction of change of the measured magnitude are sent in the connecting circuit; and at the receiving end these impulses serve to move a recording stylus up or down the scale of a

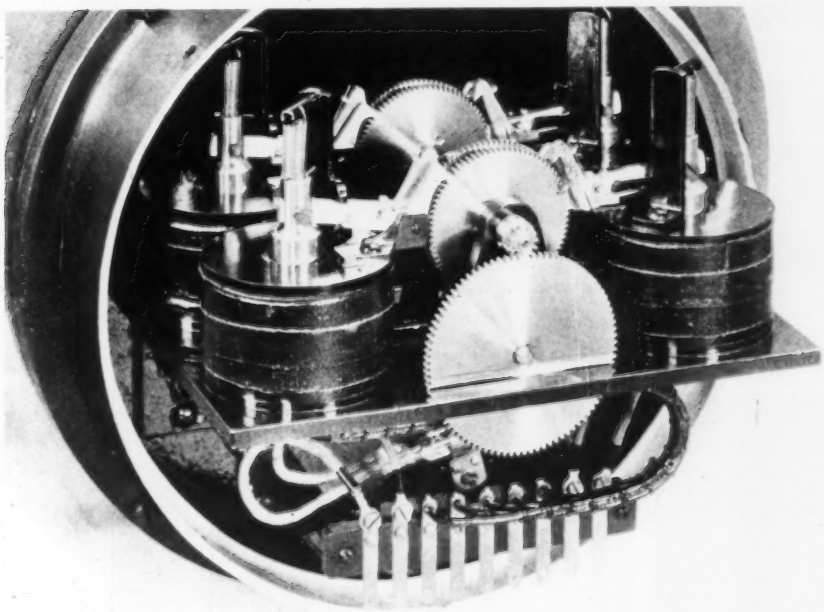

Fig. 44-57

record chart, thus providing a continuous graph of the measured variable. The apparatus is supplied in several forms, one using a two-conductor circuit and having a source of power at the transmitting end, and the other using a three-conductor circuit with all power supplied to the system at the receiving end. Fig. 44-57 shows the mechanism of a two-element impulse-type indicating receiver, the actuating solenoids and ratchets being distinctly visible. In Fig. 44-58 is shown a continuous recorder operating on the same principle, the enclosing cases of the solenoids being seen beneath the base of the instrument. The general nature of the impulses in this system is as shown at (*c*) in Fig. 44-55.

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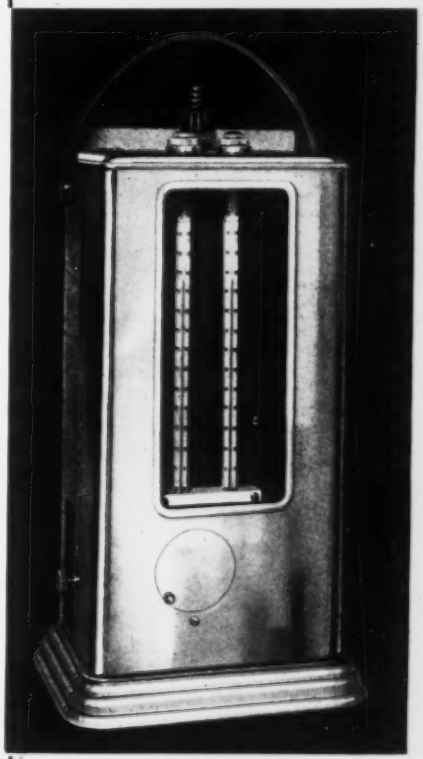

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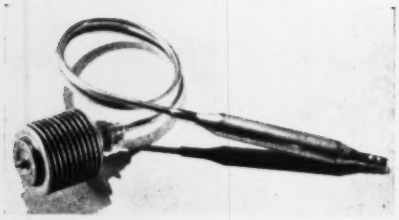

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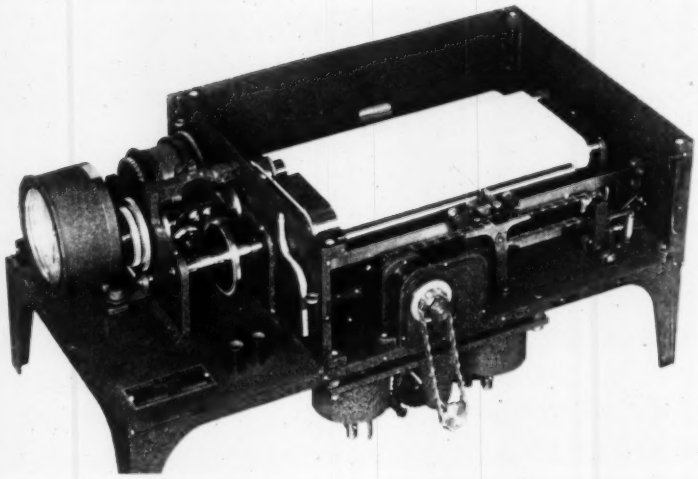

Fig. 44-58

MacCreedy Fluid-Level Indicator.

In the MacCreedy fluid-level indicator supplied by J. H. Bunnell & Co., use is made of a three-conductor circuit, one conductor being ground. Impuses

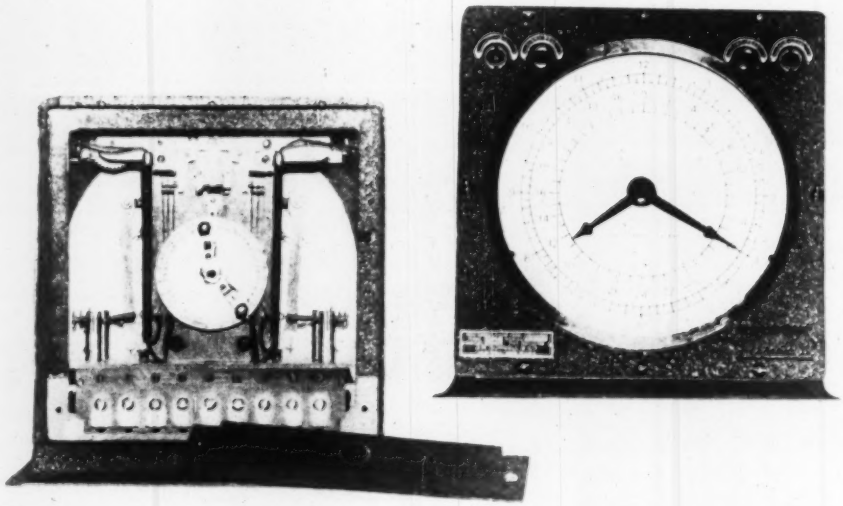

Fig. 44-59

are transmitted over one or other of the line wires according to the direction of travel of the float, and an electromagnetically operated ratcheting device at the receiving end serves to position an indicating pointer. Fig. 44-59 shows a MacCreedy receiver.

Ericsson Water-Level Indicator.

The Ericsson Water-level Indicator, Fig. 44-60, is particularly suited to installations where considerable power is available at the transmitting end of the system. The transmitting unit contains a d-c. generator driven from a float

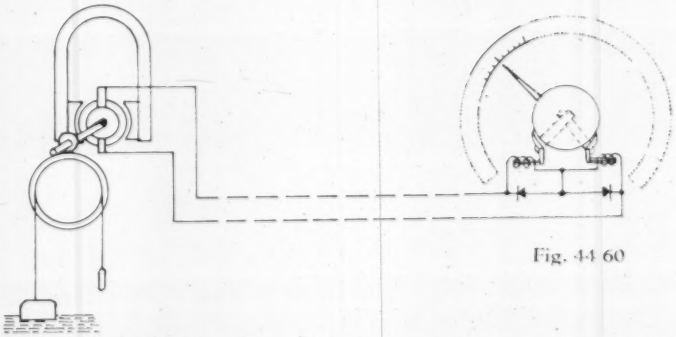

Fig. 44-60

through a spring coupling, so that as the float moves the armature rotates with successive abrupt movements, thus imparting to the circuit a series of electrical impulses of the general nature shown at (*d*), Fig. 44-55, depending in polarity

upon the direction of travel of the float. The receiver includes a ratchet wheel driven in either direction by one or other of two pawls actuated by solenoids. The solenoids are connected in series, and each is shunted by a rectifier, so that only one solenoid is operated at a time, depending upon the polarity of the impulse, and hence upon the direction of travel of the float. Thus, the position of the receiving indicator becomes a measure of that of the float.

Kennedy System.

Designed particularly for the transmission of pressures and liquid levels, the "Telemetric Gauge," supplied by J. S. Kennedy, possesses the unique feature that the indicating pointer of the receiving unit always advances in the one direction about a circular dial, coming to rest in positions corresponding to the level as measured at the transmitting end. Thus, upon a rising level, the pointer progressively advances to higher indications, while with a falling level, the pointer rapidly sweeps around the scale and comes to rest at the new reading

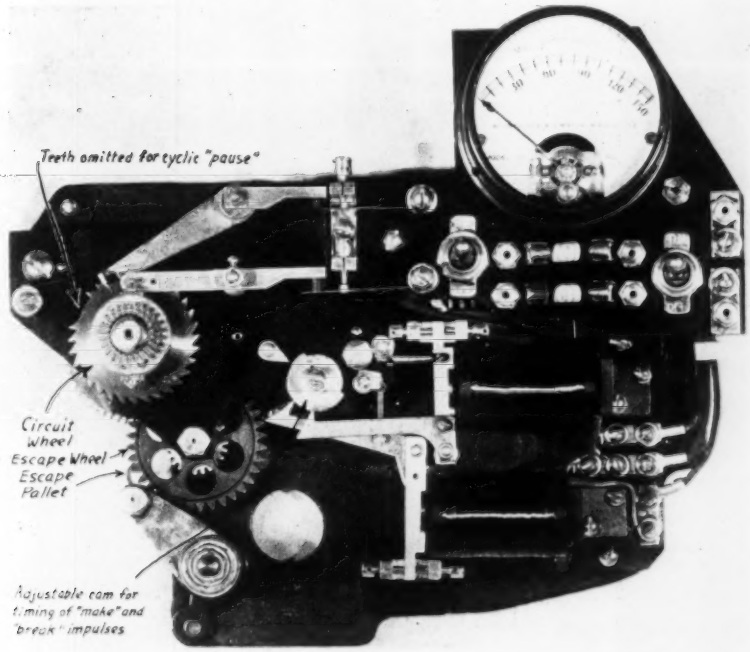
Teeth omitted for cyclic "pause"
Circuit Wheel
Escape Wheel
Escape Pallet
Adjustable cam for timing of "make" and "break" impulses

Fig. 44-61

below its starting position. The transmitting unit shown in Fig. 44-61 includes a differential gearing positioned jointly by a clock mechanism and the measured magnitude so that the planetary member of the gearing comes to rest in a position where a contact is maintained by it in a closed condition. Upon any movement of the planetary, in response to a change in pressure or level, the circuit is opened, releasing the clockwork, which acts to rotate the differential always in the one direction. An impulse wheel associated with the differential makes intermittent contacts until the planetary member is returned to its original position, when the main contact is again closed, locking the mechanism against further rotation.

The receiver mechanism is actuated by a pawl-and-ratchet which responds to the impulses set up by the contactor in the transmitting instrument, advancing the pointer around the scale with the movements of the planetary of the transmitter differential. Thus, as the level rises, the pointer will progressively step to the corresponding indication, and in the event of a lowering of the level the transmitter sends a succession of rapid impulses, causing the pointer to sweep quickly around the scale until it reaches a position below its starting point and corresponding to the newly reached level. By omitting two teeth in the transmitter ratchet wheel, there is introduced a "long" impulse in the series, and by making adjustments so that the receiver pointer passes through zero as the corresponding "pause" comes over the line, the system is made self-checking. The general nature of the impulse groups in the line is shown at (*e*) in Fig. 44-55. The Kennedy system is one of the oldest on the market, some installations made more than twenty years ago being reported in service at this writing.

Proebstel's Water-Stage Indicator.

A water-stage indicator developed by D. W. Proebstel* embodies what the inventor styles a "d-c. synchronous motor," and requires generally five con-

* U. S. Patent No. 1,229,785. D. W. Proebstel. June 12, 1917.

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ductors between transmitter and receiver. In this device the float at the transmitter is attached to a two-part reversing commutator having three brushes evenly spaced about its periphery, and each connected to one conductor of the transmitting line. The receiving unit includes a four-pole electromagnet rotatable in a six-pole field structure. The field windings are "Y-connected" and supplied from the three transmitting lines, and the rotor is permanently excited from a d-c. supply. This combination permits the rotor to be positioned by definite increments of 1/12 revolution in response to movements of the commutator; and by suitable gearing the rotor is caused to position an indicating pointer or a recording stylus.

Sangamo Distant Dial.

The Sangamo Electric Company's "Distant Dial," widely used for providing remote registration of watthour meters, employs an operating principle depending entirely upon reversal of current through a circuit supplying the two main solenoids of the receiving unit. A double-contact mechanism shown in Fig. 44-62 is directly operated from the watthour meter, and impresses on the line a series of impulses of alternate polarity [see (*b*), Fig. 44-55] derived from a constant source at the transmitter. This periodically reversed current is received in a polarized relay device shown diagrammatically in Fig. 44-63. The solenoids 2 and 3 are of opposite polarities, and over their pole pieces 9 and 10

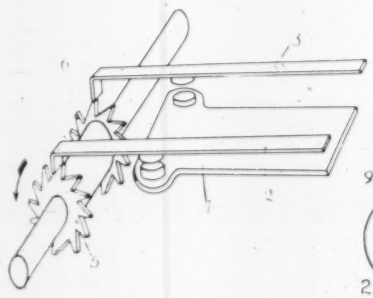

Fig. 44-62

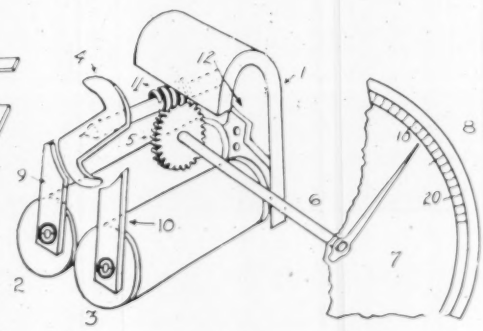

Fig. 44-63

moves a Z-shaped soft iron armature 4. To the common yoke 12 of the solenoids is attached a permanent magnet 1, which, through the steel worm-shaft 11 serves to polarize the armature 4 carried thereby. With this construction it will be seen that currents of alternate polarities in the solenoids will cause the armature to advance a quarter-turn for each reversal. The worm-shaft 11 being meshed with a suitable worm wheel, the relay is caused to rotate a register which may be a duplicate of that in the watthour meter. Totalization of the registrations of several meters may be effected by the use of reversing commutators in the additional transmitters, the current being reversed for each unit of advance in each meter, so that the receiving dial shows a total of the energy metered in the individual units. By making the reversing commutators of a quick-acting design, the possibility of error due to simultaneous reversals in different transmitters has been made practically negligible. This Sangamo system is used also for remote counting and totalizing of engine revolutions, pump strokes or other recurrent events.

(c) Impulse-frequency Type.

The principle of telemetering by the use of a series of impulses occurring at a frequency governed by the measured magnitude is particularly adaptable to use with registering type (rather than deflecting type) primary measuring units, such as rotating and oscillating fluid meters and electricity meters. In the measurement of electric energy, the impulse principle is inseparably associated with the determination of demand, and reference to the preceding articles* on demand measurement will disclose a considerable number of devices in which the demand element of an instrument is actuated by impulses originating with the moving part of a watthour meter and electrically transmitted to a considerable distance if desired, in which case the combination becomes a demand telemetering system.

When a determination of *demand* is required, the receiving instrument contains an indicating or recording pointer which is progressively advanced by successive impulses, together with a timing element whose function it is to

*"Instruments," May 1935, pages 126-129; June 1935, pages 143-152; July 1935, pages 178-184.

reset the pointer or a driving dog associated with the pointer, at predetermined uniform intervals of time.

Where the indication or record required is of the *value* of the measured condition (*i. e.*, watts instead of kwh, or rate-of-flow rather than cubic feet) the receiving instrument must take the form of a modified "frequency meter" —a device which will translate the frequency of the impulses into a linear magnitude which may be expressed by the excursion of a pointer or pen-arm over a graduated scale.

The impulse-frequency and impulse-counting systems are closely related, the impulses with both systems having the general nature shown at (*a*) and (*b*) in Fig. 44-55; and in many cases receivers of both types may be operated from a single transmitter.

Westinghouse "Ball Type" Receiver.

The principle of the floating ball, already described in its application to volt-ampere measurement*, has been utilized to provide a receiving unit giving a substantially continuous indication of a magnitude telemetered by the impulse system, and, in fact was originally developed for this purpose.† Referring to Fig. 44-64, an aluminum ball is supported so as to be driven by wheels W_1 and W_2, the former wheel being driven through a ratchet system from the impulses in the telemetering line, and the latter at a constant speed

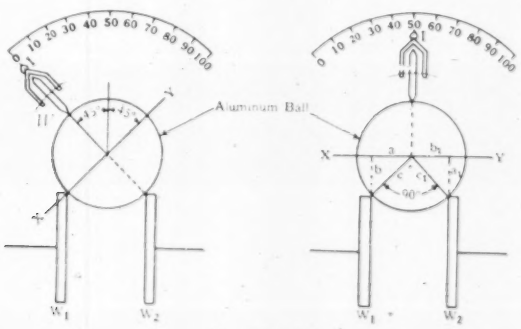

Fig. 44-64

by a small synchronous clock motor. If the speed of W_1 is zero, the ball will rotate about an axis X-Y inclined 45° to the horizontal. If the two wheels have equal speeds the axis will be horizontal, and as the speed of W_1 exceeds that of W_2, the axis will depart more and more from its zero position. The wheel W is mounted in a light movable frame so that it rolls on a great circle whose plane is always perpendicular to the axis X-Y, and the frame is free to swing about an axis passing through the center of the ball perpendicular to the plane of X-Y. This frame carries a pointer *I* which provides on an indicating scale a reading representative of the mean frequency with which the impulses are received, and therefore of the magnitude measured at the transmitting instrument.

Westinghouse Condenser Type Receiver.

The ball type mechanism described above has been to a great extent replaced as a telemeter receiver by the condenser type, in which the mechanical responding device is replaced by a simple electrical circuit having a capacitor which is charged intermittently by the influence of the incoming impulses, the indication of the receiver being made a measure of the condition of charge in the capacitor. The principle will be better understood by reference to Fig. 44-65. The method is based on the principle that when a capacitor is charged from a d-c. source it will receive a definite quantity of electricity, depending only on its capacitance and the voltage of the supply. If the capacitor is discharged before appreciable leakage can take place, the same amount of electricity will flow out again. With the arrangement shown in Fig. 44-65, the capacitor is supplied through a reversing switch, so that the charge takes place first in one direction, and then, when reversal takes place, the current flows back into the line and the condenser becomes charged in the reverse direction. A direct-current instrument placed between the supply and the reversing switch will then give a unidirectional indication, and will measure four times as much

Instruments, July 1935, page 182.
†Transmission of Power Readings, Smith & Pierce, *Transactions A.I.E.E.*, Vol. 43, 1924, page 306.
Transmission of Meter Readings, B. H. Smith, *Electric Journal*, May 1924, page 219.

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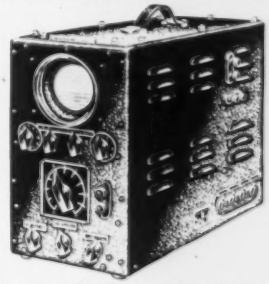

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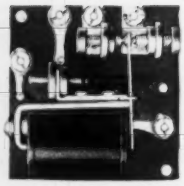

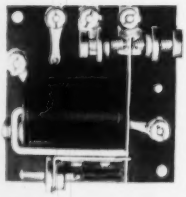

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current as would be the case if the capacitor were charged through the instrument and then discharged through a separate resistance. The electrical charges are smoothed out into a steady reading by a special circuit consisting of two units, one containing a glow tube voltage regulator, the standard capacitor and

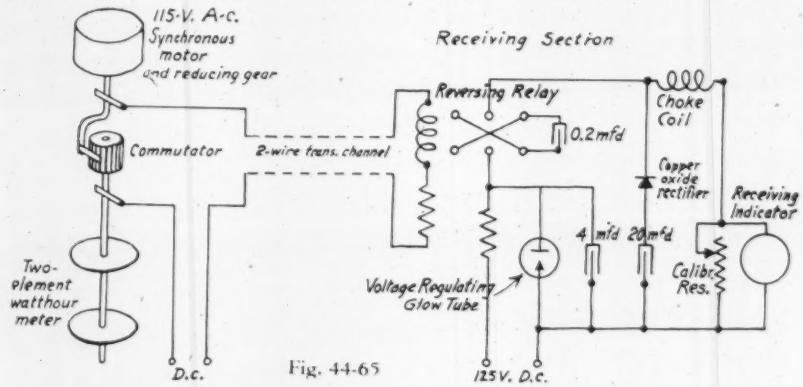


Fig. 44-65

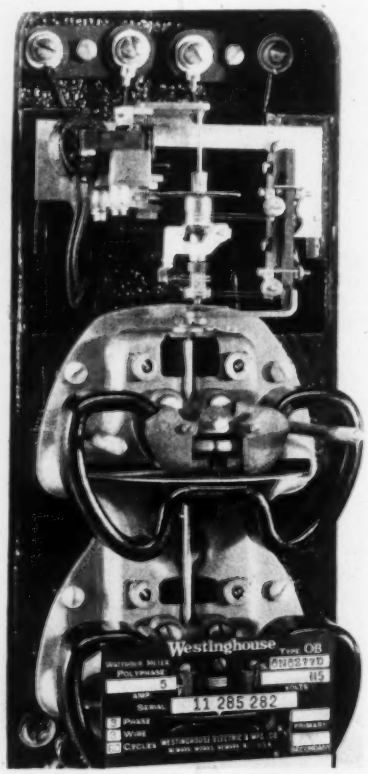


Fig. 44-66

the reversing relay, and the other an indicating or recording milliammeter. The smoothing circuit consists of a choke coil in series with the instrument, together with a condenser and a dry-disk rectifier in series, shunting the coil and the instrument. Each impulse of current passes through the rectifier and is stored in the large capacitor, whence it flows into the instrument through the rectifier in a reverse direction, thus greatly prolonging the time of discharge over what could be obtained with an ohmic resistor. The choke coil serves to reduce the ballistic kick given the movement of the instrument when an impulse is received.

This system makes use of a "base-rate" transmitter, shown schematically in Fig. 44-65 and photographically in Fig. 44-66, in which the brush structure of the meter-driven commutator is itself driven at a constant rate by a small synchronous motor mounted within the meter case, thus establishing a definite impulse rate corresponding to zero power, and permitting the transmission of impulses representing power flow in either direction. The apparatus is designed for a maximum impulse rate of 300 per minute. The receiving instrument may be indicating, recording or integrating, or any desired combination.

General Electric Magnetic Impulse System

In the magnetic impulse system of the General Electric Co. the receiving instrument includes a small transformer, saturated by means of a direct current flowing in its primary winding through a fixed resistance. A relay actuated by the transmitted impulses shunts the primary winding, permitting the flux in the core to fall to a small percentage of its initial value. The change in flux induces in the secondary winding a voltage which is applied through a full-wave rectifier to a circuit including a d-c. instrument with a capacitor across its terminals for the purpose of smoothing out fluctuations. The mean value of direct current will be proportional to the number of impulses in the line, and therefore to the speed of the transmitting meter.

Fig. 44-67 shows a transmitting section having a G-E "DS-19" watthour meter equipped with telemetering contacts which actuate the relay below it. Fig. 44-68 shows a typical receiving section: at the bottom the receiving relay, at the left a recording instrument here used as a recording wattmeter, and at the right the impulse-frequency device which operates the recorder. This de-

Fig. 44-67

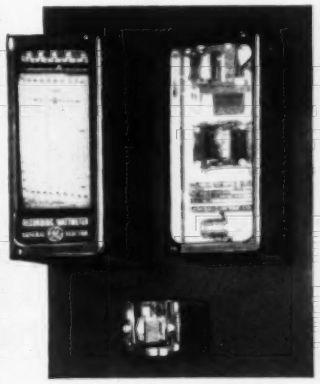


Fig. 44-68

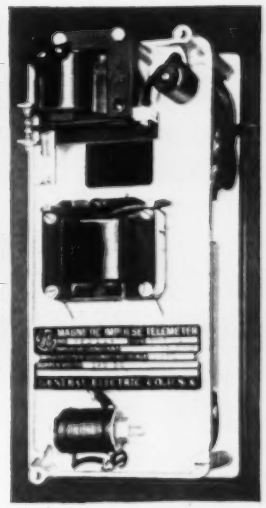


Fig. 44-69

vice, the "Type TR Impulse Telemeter," is shown with cover removed in Fig. 44-69; at the top are the shunting relay and the adjusting resistor, at the center is the reactor and at the bottom the copper-oxide rectifier.

(d) Impulse-spacing Type.

In impulse-spacing systems it is required that an element of the receiving instrument operate synchronously with an element of the transmitting unit, thus establishing identical and concurrent time intervals in the two. This requires either that both instruments be driven by synchronous motors from a common source, or that there be provided special auxiliary devices to establish synchronism periodically. Within the time intervals so established, impulses—generally of short duration—are originated by the transmitter, the time of occurrence of each impulse in its corresponding interval being made a measure of the magnitude transmitted. The impulses in the line will take the general nature shown at (*f*) in Fig. 44-55.

Roucka System.

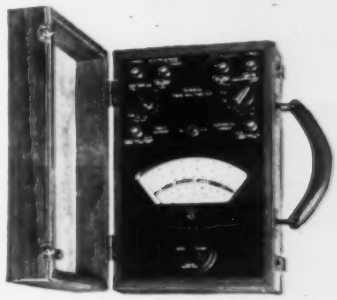
Although the idea is an old one, what might be called the prototype of the practical impulse-spacing systems on the market is found in the system patented by Roucka.* The transmitter and receiver include each a synchronous motor, these being driven from a common source and serving to establish concurrent isochronous time intervals in the two units. A contactor driven continuously by the transmitter motor engages a fixed contact at what corresponds to the zero point of the primary measuring element, and superimposes on the d-c. connecting line (or on a separate circuit) an impulse of d-c. power. When the moving contactor passes the pointer, at a position representing the then value of the measured magnitude, a second impulse is transmitted. The receiving instrument includes a pointer continuously driven by the synchronous motor, and so spaced that as the first of the abovementioned impulses is received an electromagnet forces the pointer momentarily against a strip chart, making a dot which serves as a zero of reference. As the second impulse occurs a second dot is made, indicating on the chart the position of the transmitting pointer. The transmitter contact and the receiver pointer continue to travel in synchronism until the fixed contact is engaged and another cycle initiated. The record thus takes the form of a series of dots, constituting the contour of a curve representing the values of the measured magnitude.

The "Telautogage."

The impulse-spacing system is exemplified in American practice by the "Telautogage," manufactured by the Electric Indicator Corporation. The transmitter, Fig. 44-70, includes a small synchronous motor *1*, which drives an angularly rolling disk 2 through a crank 3 mounted on the motor shaft, so that the disk, centered on a ball-and-socket joint 4, partakes of a nutating motion with its edge rolling on a ring 5, making one revolution about the ring every 30 seconds. The ring 5 is carried on a set of rods 6 and bears an arm 7, the whole being mounted on ball bearings and free for limited axial motion in tubes 8. A light spring holds the edge of the ring 5 normally in engagement with the edge of disk 2. An adjustable screw 9, threaded into the arm 7, bears against a lever *10*, by which a mercury switch *11* is operated by a slight movement of the ring structure. To the lower center of the ring 5 is attached a

* U. S. Patent No. 1,597,828. E. Roucka. August 31, 1926.

Rawson Twin Multimeter



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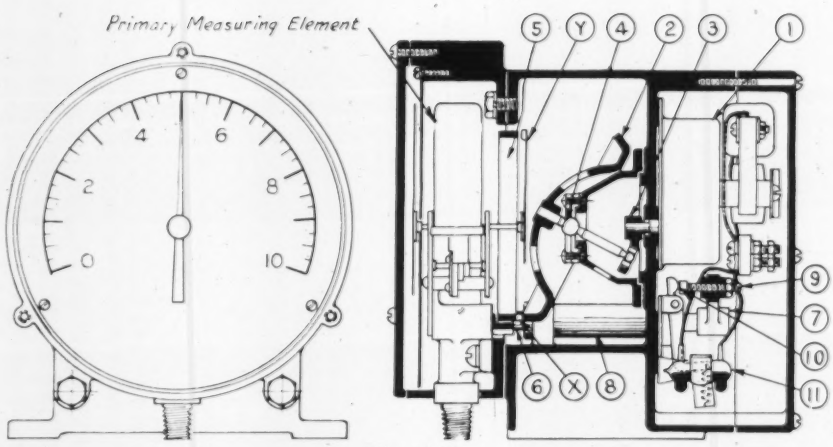


Fig. 44-70

V-shaped block X, causing the ring to move forward slightly as the disk rolls over the block, thus actuating the switch *11* and causing an impulse to be sent out every 30 seconds. A spring pointer Y, attached to the primary measuring unit (here shown as a Bourdon tube) is also fitted with a small V-shaped block which rests close to the ring in the path of the disk, so that, as the latter rolls around, the block is caught between the disk and the ring, moving the latter, and causing a second impulse to be sent out on the line. The V-blocks are so designed that the fixed block X causes an impulse of 2 seconds, and the movable block of Y an impulse of 4 seconds, to be sent out on the line. It is evident that the interval between these impulses in each cycle will depend upon the position of Y, and will consequently represent the measured magnitude.

The receiver, shown in Fig. 44-71, contains a synchronous motor, driving an indicating pointer *12* through a magnetic clutch assembly consisting of friction disks *A* and *B* and coil *C*. The clutch is normally held in engagement by pressure of the spring *D*, driving the pointer steadily around the scale at a rate of

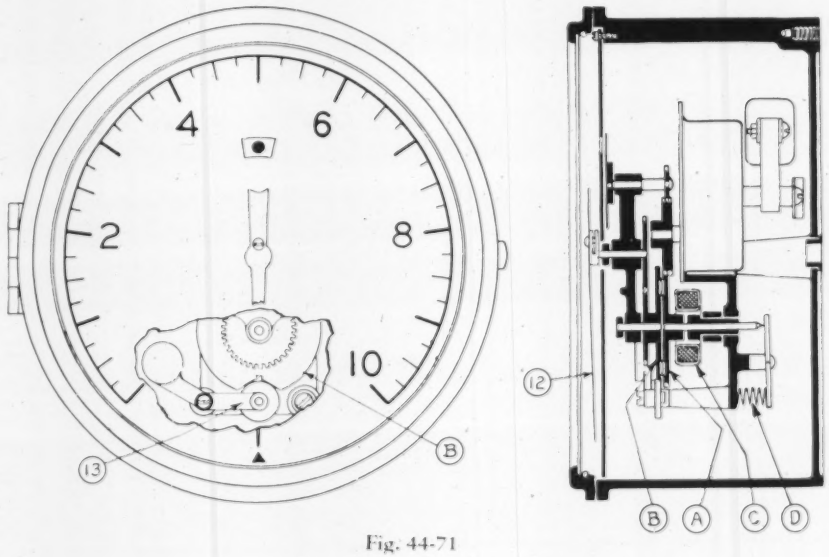


Fig. 44-71

one revolution in 24 seconds. As the clutch is energized by impulses from the transmitter, the pointer is released, first for an interval of 2 seconds, corresponding to the check point on the dial, and then for an interval of 4 seconds, representing the position of the measuring pointer, and giving the observer ample time to read the position of the indicator on the scale. The total time of 24 + 2 + 4 seconds makes up the half minute representing the normal cycle. In case of the receiver and transmitter getting out of step, re-synchronization is effected by a weighted lever *13*, carrying a roller which centers itself in a V-shaped notch in the disk *B* when the latter is released at the checking point in each cycle of operation. Thus, errors due to non-synchronism of the motors in the respective units are prevented from becoming cumulative.

(e) Impulse-duration Type.

In systems of this type impulses occur at substantially uniform time intervals, and the duration of each impulse is determined by the magnitude measured at the transmitter. The general nature of the impulses in the line is shown at

(g) in Fig. 101, where the impulses are shown as beginning isochronously and terminating at instants varying with the measured magnitude.

Foxboro Distance Transmission System.

The Foxboro Company's "Distance Transmission" system may be operated from any standard type of measuring device in which the position of a pointer is determined by the magnitude—temperature, pressure, flow, liquid level, humidity, etc. In the transmitter, Fig. 44-72, which is operated by a synchronous motor, a brake holds the pointer in the last position, being released once a minute to permit the pointer to take its true position. After the brake has been re-engaged a cam which is continuously rotating positions a contactor and closes the transmission circuit, the contactor being retained in this position by means of a latch. As the cam continues its rotation its follower traverses the plane of the pointer travel at a constant speed, eventually engaging the pointer in its braked position, unlatching the contactor and opening the circuit. Thus there is sent through the transmitting line each minute a time impulse the duration of which is a function of the value under measurement.

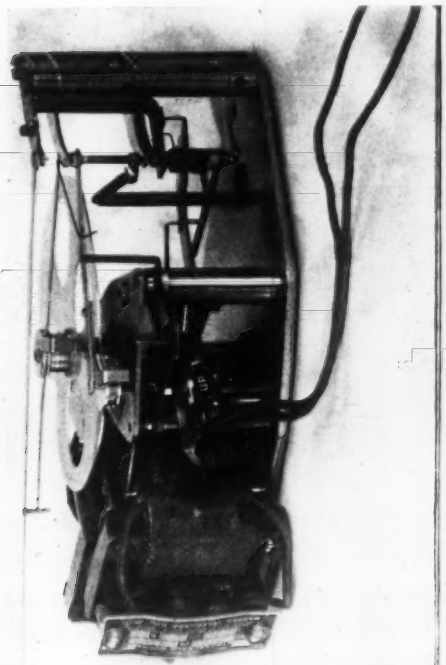


Fig. 44-72

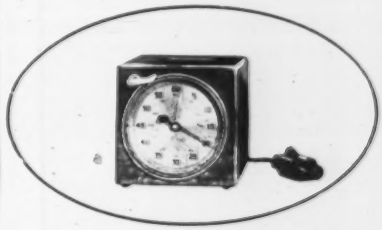
Fig. 44-73

The receiver, Fig. 44-73, includes a timing motor operating synchronously with that in the transmitter. As each impulse is received, a pointer-propelling arm is caused to advance for the duration of the impulse in synchronism with the transmitter-cam-follower. At the end of each impulse the pointer-propelling arm stops at a position corresponding to that of the transmitter pointer. On increasing values the pointer will be carried up the scale with the arm, and on decreasing values the pointer is brought into engagement with the arm at its position of maximum excursion, after which the arm is returned to its initial position ready for the next impulse. The receiving mechanism cycle is completed in fifty seconds, providing a margin of ten seconds to permit the receiver to be synchronized with the transmitter in the event of their having been thrown out of synchronism from any cause.

The "Chronoflo."

In the "Chronoflo," developed originally by Builders Iron Foundry as a flow meter,* the transmitting section, Fig. 44-74, includes a synchronous motor driving at a uniform speed a cam which causes a switch periodically to engage a rod attached to the float of a mercury manometer or equivalent device. The time of engagement and disengagement of the switch is governed by the contour of the cam and the height of the rod, so that there are impressed on the line impulses whose durations will vary with the height of the rod. The con-

*Instruments, October, 1932, page 233.



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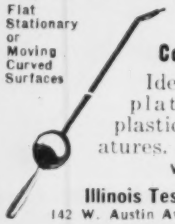

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MANUFACTURERS' NEW LITERATURE

In this department we list each month the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

D1 **Contactors.** Folder No. 1145 describes the new E. C. & M. Line-Arc contactors for crane, mill and machinery controllers. Electric Controller & Mfg. Co., Cleveland, Ohio.

D2 **Open Hearth Control System.** Leaflet E-174 briefly covers the control of combustion, pressure, reversal and roof temperature. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

D3 **Thermocouple Protection Wells.** Bulletin 437 gives data on Brisrome wells. Bristol Co., Waterbury, Conn.

D4 **Radio Instruments.** Circular R-1-E illustrates and briefly describes the Weston Radio Instruments: Tube-checker, Selective Analyzers, Capacity Meter, Volt-Ohmmeters, Ohmmeters, Output Meter, etc. Weston Electrical Instrument Corp., Newark, N. J.

D5 **Optical Aids in Metal Working Industry.** Bulletin D-216, 16 pages, is a condensed listing of instruments useful in routine production, inspection, research and experimental work. Bausch & Lomb Optical Co., Rochester, N. Y.

D6 **Photoelectric Potentiometer** Model 721 gives a brief description and lists a number of applications. Weston Electrical Instrument Corp., Newark, N. J.

D7 **Graphic KVA Meter.** Bulletin 735 gives the principle of operation as well as other data on this instrument. Esterline-Angus Co., Indianapolis, Ind.

D8 **Air Meters.** Bulletin No. F gives information on the instrument as well as operating instructions. Julien P. Friez & Sons, Inc., Baltimore, Md.

D9 **Polyranger.** Bulletin Oct. 1935 covers a number of multiple range electrical measuring instruments. The Universal Polyranger has 13 d-c. ranges and 14 a-c. ranges. Sensitive Research Instrument Corp., 4545 Bronx Blvd., New York, N. Y.

D10 **Saccharimeters.** Bulletin D-229, 8 pages, describes the half-shadow saccharimeter with international sugar scale (Bates-Jackson conversion factor). Bausch & Lomb Optical Co., Rochester, N. Y.

D11 **Relays and Relay Mountings.** Catalogue 4016-A gives general data on Autelco relays. Specifications, engineering data and illustrations of all relays are given. American Automatic Electric Sales Co., 1033 West Van Buren St., Chicago, Ill.

D12 **Instrument Transformers.** Leaflet D.M.E. 5679 covers data and application of instrument transformers. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

D13 **Time Switches.** Filing No. 6500, 8 pages, describes the construction and applications of general-purpose automatic-time switches. General Electric Co., Schenectady, N. Y.

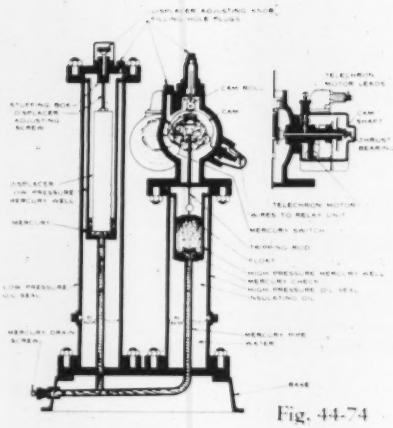

Fig. 44-74

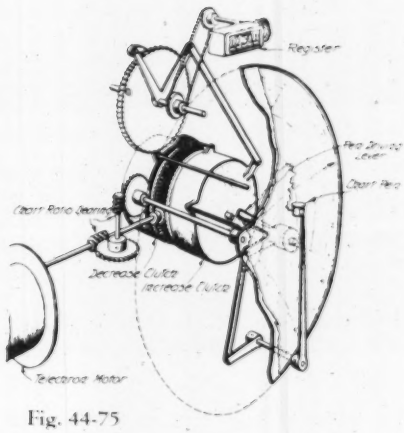

Fig. 44-75

tour of the cam takes the form of two opposed and similar spirals, so that the mid-points of the successive impulses are isochronous (rather than the beginnings as shown in Fig. 44-55). The form of the spiral can be made such as to compensate for non-linear characteristics in the measuring unit; and by conforming it to a square-root law, the lengths of the impulses may be made directly proportional to the flow through an orifice or a Venturi tube. While the "Chronoflo" transmitter is here described as having a spiral cam, it is now produced with a cylindrical cam, the working contour having a helical conformation. This new transmitter is sealed, obviating the need for stuffing boxes. The receiving unit, Fig. 44-75, takes the form of a mechanism having a pair of electromagnetic clutches driven from a constant-speed motor and associated operating dogs or pushers which tend to impel an indicating pointer or recording pen-arm in either direction, according to which clutch is engaged. Circuit connections are such that one clutch is engaged when the circuit is closed at the transmitter and the other when the circuit is open. Thus the pushers are alternately actuated in response to the value of the measured magnitude, dropping back to a zero stop when released, so that the indicating or recording member will take up on the scale a position representing their relative times of engagement, and will be subjected to a positioning influence alternately from above and below, providing a definite measuire of the magnitude represented by the height of the rod in the transmitter.

Integration is effected by the simple expedient of driving a counting train through a ratchet from the clutch whose function it is to impel the recording member toward the top of the scale.

There is no need of absolute synchronism between transmitter and receiver, nor of corrective means to synchronize units operating at the same nominal speed.

Bristol's "Metameter."

The "Metameter," built by the Bristol Company, operates on the same essential principle as the "Chronoflo" described above. The transmitter, Fig. 44-76, includes a continuously rotating spiral cam on whose flat surface rides the tip of the pointer of the primary measuring element. The pointer-tip or rider is free to move through a short distance perpendicular to the face of the cam, and is periodically lifted by the leading edge of the cam, always at the same instant in the cycle. Through the medium of a magnetically operated mercury switch, the rider acts to close a contact, which remains closed until the rider drops off the trailing edge of the cam. With the pointer deflecting radially across the face of a spiral cam, the duration of the contact interval becomes representative of the deflection; and by suitably shaping the cam the length of impulse may be made to follow any desired law in relation to the measured magnitude. The nature of the impulses is as shown at (g) in Fig. 44-55. The normal cycle of operation is 15 seconds.

The receiving instrument, Fig. 44-77, includes a mechanism having a pair of differential gear trains, driven by a constant-speed motor, and arranged so that dogs or pushers attached to their respective planetary members tend alternately to position the pointer in opposite senses. Normally, each differential train runs free, and its planetary is held against a zero stop by a light spring. A braking member, operated by an electromagnet, is arranged to check one or other of the free-running trains, whereupon the corresponding planetary immediately begins to rotate and its associated pusher to act in a sense to impel the pointer in a corresponding direction across the scale. The electrical circuit is such that the magnet is energized and one train activated during the time

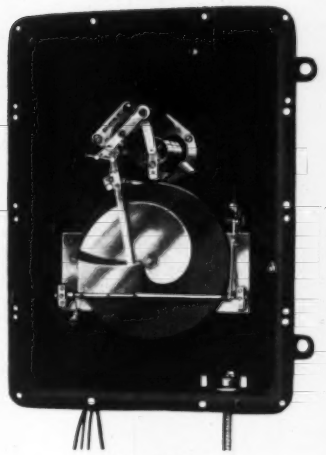

Fig. 44-76

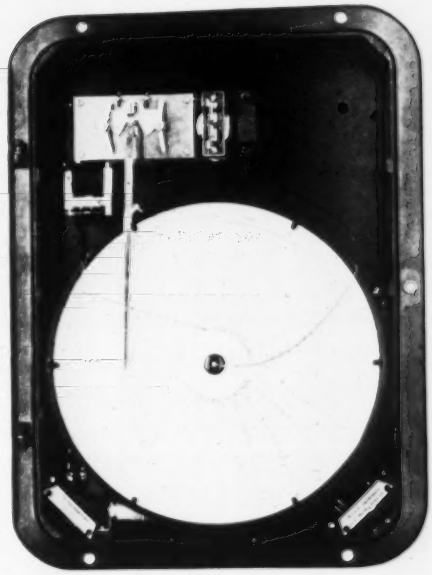

Fig. 44-77

the transmitter pointer engages the flat cam, and the other train activated during the interval when the pointer is clear of the cam. The resultant action, therefore, is to position the indicator at a point on the scale coresponding with the deflection of the primary measuring element. This instrument is available as an indicator, a recorder, a controller, or with various combinations of these functions. Provision is also made whereby more than one Metameter system may be operated over a single two-conductor circuit.

In this system, too, absolute synchronism between the motors in the transmitting and receiving units is not essential, actual differences in speed introducing second-order errors: (*a*) if the receiving motor be running too fast in relation to the transmitter, the tendency of the instrument will be to "overshoot" and record alternately above and below the true value; (*b*) if the receiver is running too slowly, there will be a "zone of uncertainty" in its readings, the true value lying generally in the middle of this zone. Thus it is not essential that the transmitting and receiving instruments be driven from the same source of electric energy, and transmission may be effected with a true two-conductor circuit.

Elgin "Isometer."

The "Isometer," produced by the Elgin Softener Corporation, is primarily a flow meter of the area class, gate type (in which the orifice is automatically adjusted to maintain a constant differential). The telemetering device forms an attachment to the orifice mechanism, the value of the measured flow being represented by the position of a rod directly connected to the self-balancing orifice-plate. A contact-arm moved by the rod is periodically engaged by a constantly rotating cam, and actuates a contactor to govern the durations of successive electrical impulses in the line. Since the orifice operates at a constant differential, the characteristic square-root law of flow meters does not enter into the operation; and, by properly designing the orifice plate, the deflection of the balancing mechanism is made directly proportional to the flow. The mechanism which receives the electrical impulses is identical to that of the transmitter and is driven by a synchronous motor from the same a-c. power source. The contact arms in the two units rise and fall in unison, so that if their respective contacts are in identical positions simultaneous contacts will be made. The recording element includes a pen driven in either direction by a small reversible double-field motor; and when the receiver is contacting in unison with the transmitter both fields are simultaneously energized and de-energized, with no resultant motion of the recording element. Should either contact be made before the other, the corresponding field will receive power for a longer interval, with a resultant motion on the part of the pen and of the contact-arm, this action being continued until a new position of balance is assumed. Thus the pen tends at all times to take up a position in which the impulses originating in the receiving unit are of duration equal to those set up by the transmitter, and hence in a position which is a measure of the orifice opening, and therefore of the rate of flow. The integrating mechanism consists of a direct-reading counter driven by a small synchronous motor energized in response to the impulses transmitted through the line.

D14 **Magnetic Chuck Rectifiers.** Bulletin 8651 shows connection diagram, dimensions and capacities of magnetic chuck rectifiers. Ward Leonard Electric Co., Mount Vernon, N. Y.

D15 **Speed Control Handbook.** 112-page, cloth bound book has the following chapters: Why Variable Speed Control is Essential in Modern Manufacturing; Development of Variable Speed Control; Qualifications of Modern Speed Control Equipment; The Reeves Transmission—What it is and What it does; Units & Controls in the complete line of Reeves Transmissions; Features of Reeves construction; How the Reeves is Used by Machine Designers; How to Select the Right Unit for Your Requirements. Reeves Pulley Co., Columbus, Ind.

D16 **Regulator for the Control of Diaphragm Valves & Damper Motors.** Bulletin 226, 10 pages, gives engineering data and diagrammatically illustrates typical applications. Powers Regulator Co., 2720 Greenview Ave., Chicago, Ill.

D17 **Time Switch.** A 52-page handsomely printed book celebrating the 25th anniversary of the Sauter time switch. Scenes of the plant, of Basle and other Swiss scenes are included. Copies can be obtained from H. W. Cramer & Co., Inc., 6769 Irving Place & 18th, New York, N. Y.

D18 **The Microscope, its Construction, Use & Care.** 64-page book gives a brief outline of the mechanical and optical principles involved, with special reference to efficient manipulation. Spencer Lens Co., 19 Doat St., Buffalo, N. Y.

D19 **Optical Pyrometer.** The Pyrometer Instrument Co., 103-107 Lafayette St., New York, N. Y., have published a new illustrated catalogue No. 70.

D20 **Maximum Demand Register.** Bulletin No. 88 briefly describes the instrument and its operation. A table gives Register ratios, pusher arm ratios, number and value of divisions and full scale values for Sangamo type HG demand registers. Sangamo Electric Co., Springfield, Ill.

D21 **Relief Valves.** Bulletin 135 illustrates the new cup disk relief valve. A diagram gives comparative tests of 1" relief valves on water. Klipfel Mfg. Co., 2641 W. Harrison St., Chicago.

D22 **Precision Portable Potentiometer.** 8 page bulletin covers this instrument as well as a portable high-resistance pyrometer. Thermo Control Devices, Inc., Chicago, Ill.

D23 **Meteorological Instruments.** Three new catalogues have been published: 21E on Instruments for Air Pressure, Temperature and Humidity; 22E on Instruments for Wind, Rain and Precipitation, Evaporation, Radiation and Visibility; 40E on Instruments for the Measurement of Water Levels and Quantities. R. Fuess, Inc., 245 W. 55th St., New York City.

D24 **Tube Testers.** To those readers who are interested in test instruments design or who are making their livelihood from the repair of radio receivers, the Supreme Instrument Corp. of Greenwood, Mississippi, manufacturers of radio test instruments, offers a 16-page booklet "The Evolution of Tube Testing."

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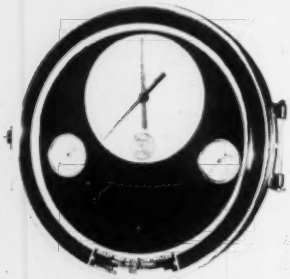
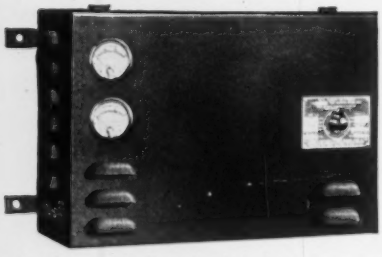


when the controller is in operation. The setting is made by turning a knurled knob located under the indicating dial. A sensitivity adjustment is also provided whereby the "control range" may be varied from 1% to 1000% of the measuring range. Inside the casing a Bourdon tube type pressure spring actuates both the indicating pointer and a free-floating air pilot valve. Inlet and outlet air pressures to this pilot are indicated by small gages on either side of the main indicating dial and connections for air supply and control pressure are made through the rear of the casing with ¼" o.d. copper tubing. *Bailey Meter Co., 1054 Ivanhoe Rd., Cleveland, Ohio.*

Controlled Rectifiers

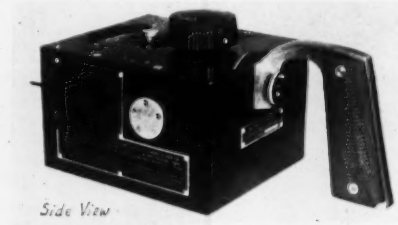
Development of a line of controlled rectifiers to supply a d-c. output from a commercially constant, single-phase, 110-volt a-c. line is announced. The output

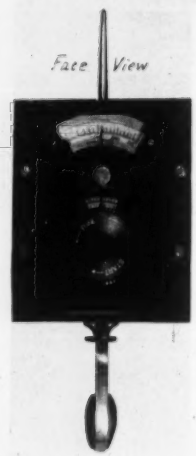


voltage regulation is 2% from approximately one-tenth to full load. On all sizes (covering a range from 30 watts to 250 watts) the efficiency is better than 50%, and the power factor better than 65%. Assembly consists of "Hysterset," rectifier and filter units in wall-mounting case. *Ward Leonard Electric Co., 38 South St., Mount Vernon, N. Y.*

Two-scale Vibrometer

Both amplitude and frequency are indicated by the new "Type 893 Fairbank Vibrometer," amplitude in 0.001" or in 0.1 mm., frequency in hundreds of cycles

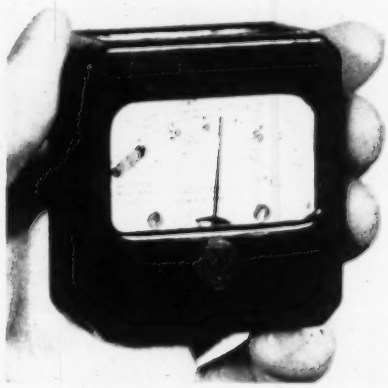




per minute. Both pointers being aperiodically damped, readings can be taken without practice. The operation is based upon the resonance of a swinging vibratory member so suspended that its natural period may be varied to match that of the object being measured. The vibrometer is provided at its front end with a threaded fitting which transmits the vibratory motion into the case as a whole. The fitting is threaded with a 5/16 S.A.E. standard thread, and different forms of nose pieces may be used. Where it is necessary to measure at a distance, the vibration may be transmitted by means of a rod. Each component can be measured separately, the instrument being sensitive only to vibration along one axis and not to motion in other directions. It will function at any angle from horizontal to vertical and hence any desired components may easily be measured. Operation: The vibrometer is held by hand against the vibrating object, or otherwise connected to it. The large knob is turned slowly in one direction. As resonance is approached, the amplitude pointer rises steadily up its scale, and when resonance is reached it shows a sharp maximum, which is the amplitude of vibration. The reading shown on the circular scale is the frequency in hundreds per minute. For large amplitudes, a correction is made on the frequency scale by moving a pointer to the amplitude reading obtained. The frequency range is 1200 to 2600 cycles per minute. The following amplitude ranges are available: 0—.015" or 0—0.5 mm; 0—.030" or 0—1.0 mm. The Vibrometer weighs 2 lbs. 8 oz. Case dimensions 5 1/16"x6 1/16". *Pioneer Instrument Co., 254 Lexington Ave., Brooklyn, N. Y.*

Pocket Illuminometer

Small enough to be conveniently tucked into vest pocket or woman's purse, a new light-prescribing and measuring device, called the "Light Meter," may be used wherever illumination appraisals are desired. Cased in mahogany-finish Textolite, it is 2¼" square and 1⅛" thick. The scale, covering 0-75 footcandles, also indicates recommended ranges for different seeing tasks, such as reading large print, office work, drafting and sewing on dark goods. Printed on the back are recommended minima for different types of work. The photocell is on top, protected by a glass cover plate and connected directly to a milliammeter movement. The cell being located on top,



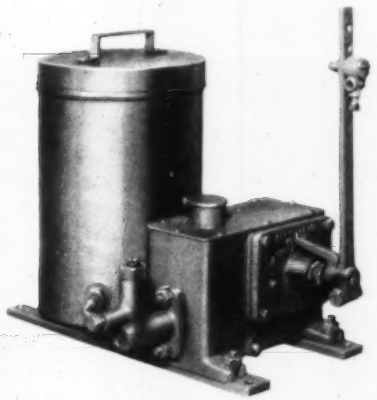
the user, in reading the scale, naturally assumes a position that will not cause his head or shoulders to intercept much incident light. Photograph shows device with cell horizontal and scale face vertical, but it may be used in other positions without impairing its accuracy. The device may be used also for determining approximate glass transmissivity, wall reflection factors, etc. Illumination values >75 footcandles can be read by applying one of two multiplying factors: By using a black card to cover up the photocell to the first marks, readings may be taken <225 footcandles; when covered to the second arrows, <750 footcandles. Zero adjustment lug is located on the back. *General Electric Co., Nela Park Engineering Dept., Cleveland, Ohio.*

Safety Limit Stops

For use as a safety device in preventing overhoisting accidents on overhead cranes, etc., an improved "Youngstown Safety Limit Stop" handles motor currents directly without the aid of additional equipment. When the limit stop is tripped, it not only disconnects the motor from the power line but brings the motor to rest quickly with minimum drift. Improvements include needle-type roller bearings, heavier gage gasketed cover, splash-proof and dust-proof design, construction capable of safely withstanding the weight of an average man. *The Electric Controller & Mfg. Co., 2700 E. 79th St., Cleveland, Ohio.*

Automatic Continuous Volumeter-feeder

Automatically feeding a liquid at a constant rate, or at a rate proportional to the speed of associated equipment, the "Type C Chemical Measuring Pump" is a calibrated-plunger type metering pump



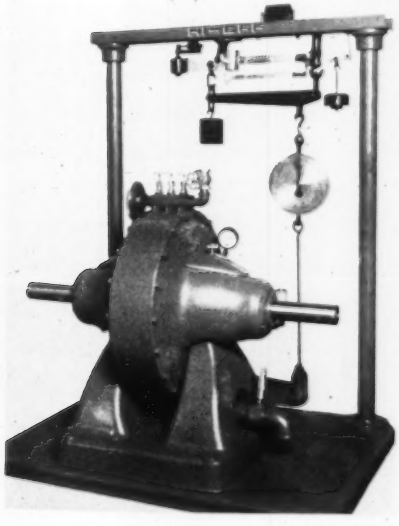
with a form of drive selected for the type of application. Three plunger sizes—

Diameter	⅜"	½"	⅝"
Cu. per full stroke	1.105	1.81	2.855
Full strokes per pint	464	284	167

—and four standard drives (ratchet, rotary 37:1, motor 68:1, and 1:1 direct rotary) are regularly available. Illustration shows ratchet drive, also 3-gallon chemical tank, this assembly being particularly designed for injecting chemicals into crude oil lines. *McCord Radiator & Mfg. Co., 2587 E. Grand Ave., Detroit, Mich.*

Dynamometer

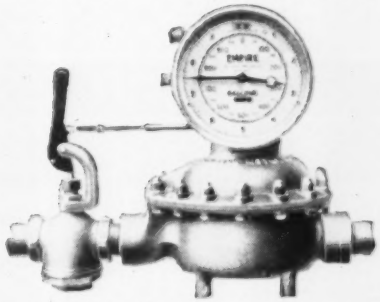
Addition of new high-speed type illustrated is reported by makers to round out their line which now includes capacities from 0.1 to 1000 h.p. and speeds from 0 to 25,000 r.p.m. Among features of new "Hi-Eff" type are steady pointer, smooth torque characteristics, micro-intake valves (minimizing water con-



sumption), no contacting surfaces between stators and rotors (minimizing maintenance costs), provisions for complete lubrication and packing-gland adjustment while running. *Taylor Mfg. Corp., 2550 W. Clybourn St., Milwaukee, Wis.*

Automatic Intermittent Volumeter-feeder

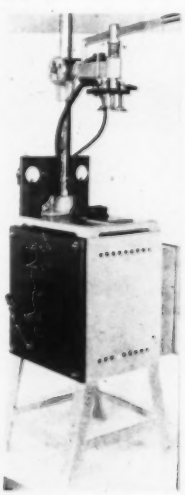
Automatically measuring off pre-set amounts of liquids on basis of volume regardless of weight, the "Measurmatic" unit consists of (*a*) oscillating-piston meter of any required capacity between



5 and 12,000 gallons per hour; (*b*) modified register which can be set to "trip" valve at any registration between 1 and 1000 gallons; (*c*) shut-off valve combining quick action and shock-absorbing device. Among operating features: (1) one man can make deliveries to remote tanks without danger of over-filling or spilling; (2) valve can be operated during run without affecting register setting. —*National Meter Co., 420 First Ave., Brooklyn, N. Y.*

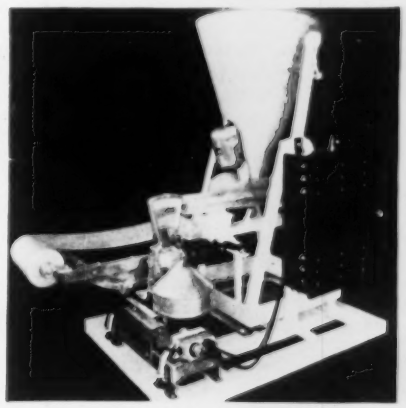
Device for Magnaflux Inspection of Steel

For inspecting tools and heat-treated parts, the new magnetizing device illustrated locates quenching cracks, grinding checks, and seams, and renders them visible when they cannot otherwise be seen. It also distinguishes between these defects and machine scratches or tool marks, which, being shallow, are generally less harmful. Parts to be inspected are placed in the machine, the contact arm dropped, and the parts circularly magnetized, after which they are inspected by either the dry method (using Magnaflux powder which, after blowing or shaking, leaves a white ridge along the line of the defect) or by the wet method (dipping the part in a light oil bath containing a suspension of Magnaflux paste; when withdrawn from the bath the defects are indicated against bright surfaces by sharply defined black lines). This device operates from a.c. mains, and no special voltages or frequencies are needed. In the smaller sizes it may be plugged in on the lighting circuit. It will accommodate parts up to 6" diam. and 20" long. Use of extension cables (optionally provided) permits inspecting larger pieces. Operation is adaptable to either occasional inspection or full production work, and requires no skill beyond that of the average inspector. *Magnaflux Corp., 323 Fourth Ave., Pittsburgh, Pa.*



Automatic Continuous Weigher-feeder

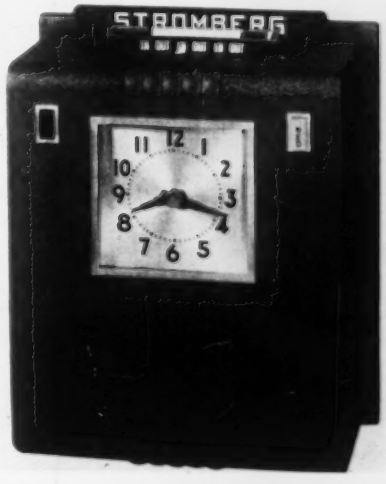
Automatically feeding dry or moist materials (other than fluids) at a constant rate on basis of weight regardless of bulk, this equipment comprises (*a*) belt conveyor driven by synchronous



motor at constant speed regardless of voltage variations; (*b*) over-and-under scale, on one pan of which conveyor assembly is mounted, other pan containing tare plus desired feed per minute; (*c*) three-speed pulsating feeder-conveyor discharging on belt and commanded by scale indicator; (*d*) supply hopper equipped with noiseless vibrator, keeping material in free-flowing condition; (*e*) electric control panel. Principal operating features are (1) use of scale purely as a scale, permitting sensitivity to fraction of an ounce; (2) use of electrical control whereby available sensitivity is not impaired; (3) continuous automatic weighing of entire load being fed. *Sautron Co., 700 No. Lexington Ave., Pittsburgh, Pa.*

"One-hand" Time Recorder

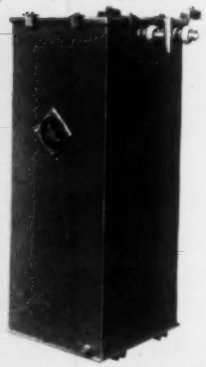
Feature of new "Model 18" electric time recorder is that it requires only one hand to operate. It is less than ¼ the size of former models, is equipped with a



Telechron motor, can be plugged into an electric light socket or may be used with a control clock, takes full-size standard time cards and prints time records on the front of the card when it is dropped in funnel face outward. *Stromberg Electric Co., 253 West Erie St., Chicago, Ill.*

Branch Feeder Regulator

A low-cost regulator, designated Type BFR, covering a 10% range in 8—1¼% steps, is responsive to voltage conditions and employs for its vital parts elements of the more elaborate station type AFR regulator. Flexibility in application is provided so the unit can operate between 10% boost and 0% boost; 7½% boost and 2½% buck; 5% boost and 5% buck; 2½% boost and 7½% buck; 0% boost and 10% buck. Standard sizes: 25 to 200 amp, 2400 volts, single or three phase; 10 to 100 amps, 6900 volts, single or three phase; 10 to 100 amps, 7620 volts single phase; 5 to 50 amps, 11,500 and 15,200 volts, three phase. *Allis Chalmers Mfg. Co., Milwaukee, Wis.*



Precision Hydrometer

For boiler water and other applications, the new "Pacometer" utilizes a thin metal stem to obtain the sensitivity required for measuring boiler saline density, without sacrificing strength. Sensitivity (in terms of stem travel per unit change of density) varies inversely as cross-sectional area of stem. A metal stem can be reduced in cross-sectional area without becoming too fragile for boiler house use. The "Pacometer" metal stem is mounted on metal prongs which firmly grip the glass bulb and align the stem with the bulb, and it can be readily detached. Temperature correction is obtained directly from a thermometric correction scale built into the bulb, obviating need of consulting charts or tables at either high or low temperature ranges such as met in boiler blow-off salines and other industrial liquids. *The Permutit Co., 330 W. 42nd St., New York City.*

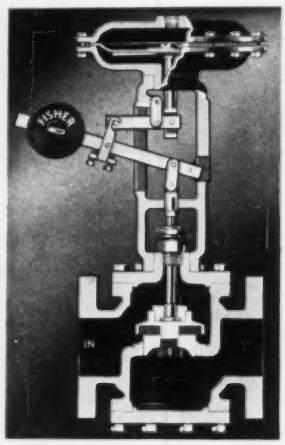
Anti-vibration Mounting

In the ney "Type-T Seismo-Damper," built in sizes from 100 to 2500 lbs. capacities, the machine is directly supported by a T-iron separated from a base of two angle irons by natural cork or other isolating material. The angle irons are firmly connected by bolts passing through the isolating materials and T-iron (but not touching it). Before installation these bolts are adjusted to precompress the isolating material to suit the machine load. Further adjustment can be made after installation. Where machine frame is light or must be

supported at several points the T-iron can be extended to form a continuous support between two or more "Seismo-Dampers" to eliminate undue bending stresses in the machine frame. *The Korfund Company, 48-15 Thirty-second Pl., Long Island City, N. Y.*

Automatic Shut-off Valves

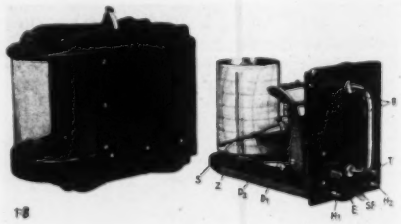
Two types: "10 K" (illustrated) closes with loss of gas pressure on diaphragm and protects positively against explosion hazards as it remains closed should gas



pressure be re-established; "10 L" closes with an increase in pressure, thereby protecting meters, etc. Both require manual re-setting. Available in sizes ¾" to 4" screwed ends, and ¾" to 6" flanged ends, for pressures on diaphragm up to 25 lbs./in.2.—*Fisher Governor Co., Marshalltown, Iowa.*

Recording Altimeter

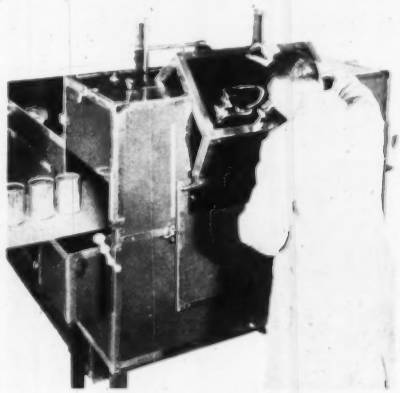
Formed of a number of diaphragms, the measuring element is said to be subjected to a special treatment minimizing hysteresis errors. Temperature compensation is achieved at diaphragms by a new system covered by German patent. Static pressure compensation (German patent applied for) obviating need for



packing and gaskets and permitting use of a light case, is optional feature, as are also two-speed chart drum clockwork and base-line pen operable manually or electromagnetically. Choice of ink or smoke-chart records: with the former, the chart scale conforms to International Standard Atmosphere; for smoke-charts the stylus deflection is linearly related to pressure.—*R. Fuess & Co., 475 W. 55th St., New York.*

X-ray Inspection Equipment

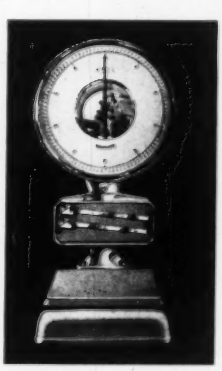
Designed to be installed in the production line, a new X-ray inspection device is preferably used as illustrated: surrounding a conveyor belt to permit inspecting packages and materials in motion, each unit thus appearing to rotate, so that a stereoscopic effect is obtained.



One control permits varying intensity; another permits operator to reject substandard units. Fluoroscopic screen—a new development—readily shows foreign substances in canned goods, etc., as well as flaws in castings, etc. Photographic and other accessories are available. *Adrian X-Ray Mfg. Co., Milwaukee, Wis.*

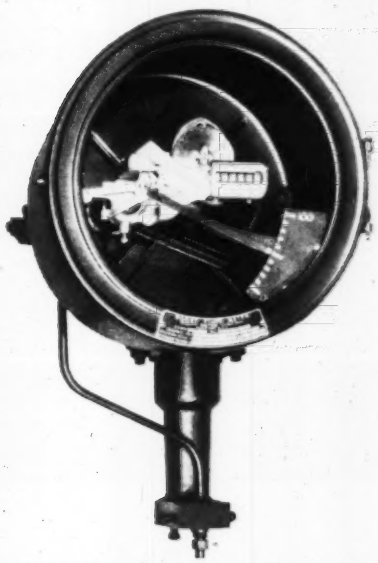
Small Bench Scale

The platform of this new small bench scale for general utility purposes is 16½"x18½" and the capacity ranges from 50 to 125 lbs. This new unit uses a Junior or smaller size dial mechanism similar to the standard Kron double-pendulum ball-bearing type. In the platform the standard Kron full-floating type of construction is utilized. This design is such that no part of the lateral motion of the platform is transmitted to the lever system. In operation all levers operate about fixed fulcrums. This means pivot and bearing wear only when a load is actually being weighed, and greatly increases the life of the scale. *The Kron Co., Bridgeport, Conn.*



Steam or Water Distribution Meter with Capacity Change

A new indicating-integrating steam or water meter with interchangeable flow mechanisms registers total steam flow on a six-digit counter, and indicates rate of flow by a pointer and scale. Recommended for services on which it is not desired to record the rate of flow, it may however be furnished with contactors suitable for the operation of a maximum demand recorder—an arrangement often



used in the sale of steam for heating. Being of the orifice type, the meter itself is not installed in the pipe line, but can be placed in any convenient location. To the high intrinsic accuracy of the orifice method of metering is added the flexibility of capacity made possible by interchangeable flow mechanisms, whereby the maximum differential head of the meter may be changed in accordance with capacity requirements.—*Bailey Meter Co., 1041 Ivanhoe Rd., Cleveland, Ohio.*

Colorimetric Testing Kits

In addition to kits for making tests for hardness, alkalinity, CO_2, etc., five colorimetric-method outfits are announced, for (1) silica, (2) phosphate,

(3) silica and phosphate, (4) oxygen, and (5) pH. Illustration shows the oxygen kit, but a standard case (5¾" x 4½" x 7¼") is used for all. Solutions are contained in small pipette stoppered bottles.—*National Aluminate Corp., 6216 W. 66th Pl., Chicago, Ill.*

Rod Thermostats

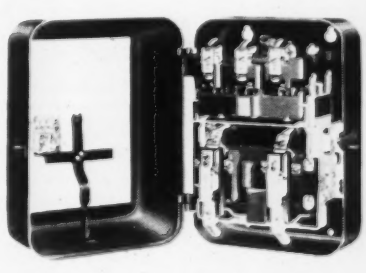
Utmost simplicity combined with greatest adjustability is claimed for new "Model D" (illustrated) and "Model N" (without outside knob) expansion-stem temperature controllers. Action is "on-and-off," inner rod operating a switch through a bell-crank lever. Maximum temperature 1800° F., normal operating limits 50° and 1600° F. Adjustable range may be as short as 100° or as long as 1000°. Differential may be ±1° or ±25° F. Snap-action switches: normally open, normally closed or double-acting or 3-wire, all rated at 10 amps., 110-v. a.c.—*Burling Instrument Co., 241 Springfield Ave., Newark, N. J.*

Muck & Marl Sampler

Presented after an exhaustive study, the "Michigan" muck and marl sampler is said to meet the needs of engineers, contractors, etc., in the public service, utility, construction and agricultural fields. Complete outfit comes in carrying case containing handle, sampler tube, seven 30" sections. With all sections assembled a sample may be taken at a depth of 20 ft. Construction is of heavy ¾" brass tubing. Sample chamber is so designed that it does not fill while instrument is pushed down with a slight clockwise motion: when proper depth is reached, operator turns handle counter clockwise, causing sample to be sheared off and forced into chamber; closes chamber by turning handle to right; and brings up sample without risk of mixing it with the soil above.—*The Rabey Mfg. Co., East Lansing, Mich.*

Motor Starter

A compact across-the-line motor starter for general purpose installations, designated "Type A-32," is rated 25 h.p. at 440 and 550 volts, 15 h.p. at 220 volts, and 7½ h.p. at 110 volts, and is furnished for push button (remote) control. Features: a new temperature overload relay designed on the melting alloy principle in which greater accuracy is said to be obtained by total enclosure of the relay in a molded case; extra-heavy silver contacts; vertical make and break, short stroke mechanism and multi-break are prevention principle. Under-voltage is also provided. Pressed steel case is equipped with knockouts for conduit connections.—*Condit Electrical Mfg. Corp., 1442 Hyde Park Avenue, Boston, Mass.*



Vibration Counters

Two new vibration counters, each having distinct fields of application, are announced. "No. 514" (Fig. 1) is especially designed for analyzing vertical vibrations and determining efficiency of damping devices on high-tension transmission lines.

Fig. 1

Weighing <1 lb., it is clamped to the conductor face down and its registrations read from the ground with binoculars. Vertical vibrations from 0.7 mm. up (0.0275") and of any frequency over 4 per second are registered cumulatively. This instrument registers only the vibrations having an amplitude >0.0275". The counters register up to 100 million vibrations and repeat, the large sweep hand registering 1 million per revolution.

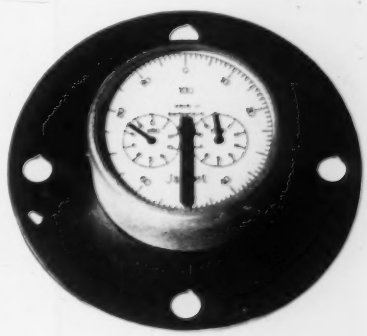
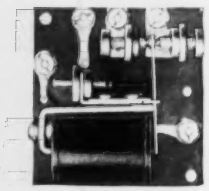


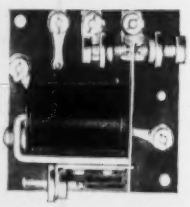
Fig. 2

"No. 515" (Fig. 2) reads in units of single vibration and can therefore be used for exact computations of resonance frequencies (with the aid of a timepiece). It is of conventional design, applicable to various types of machines and structures.—*E. W. Cramer & Co., Inc., 67-69 Irving Pl., New York City.*

Sensitive D-c. Relays

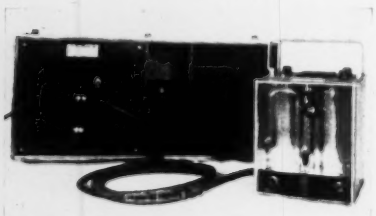
Improved characteristics are claimed for a new sensitive relay, made in two types: "Type 1C" has armature fulcrum near its end. This provides wide contact separation for small armature movement. "Type 2C" has armature fulcrum at center, reducing inertia to a minimum, thus affording high-speed operation. Both relays are rated for positive operation at 13.7 milliwatts, but can be adjusted to operate on as little as 4 milliwatts. The magnetic circuit is of high-permeability nickel alloy, exceptional in that the magnetic curve is steep at low magnetic inductions, providing good contact torque at pull-up and drop-out values. Drop out value can be adjusted to 85% of the pull-up—an especially useful characteristic when small operative margins only are available, as in photoelectric applications. Contacts: Single pole, double throw, rated to carry 1 ½ amps. a.c. 110 volts. Relays of this type can be provided to operate on voltages ranging from 0.0005 to 20, with operating currents of 0.00065 to 25 amperes. *Kurman Electric Co., 241 Lafayette St., New York City.*





High-intensity Stroboscope

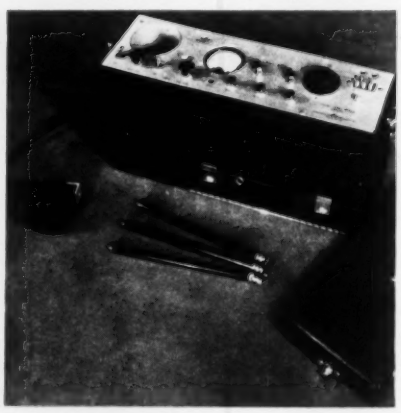
Stroboscopic images "of greater brightness than heretofore attainable with any stroboscopic device" are said to be produced by the new portable "Type PS-2 Stroboglow," its lamp being of 300,000 c.p. and having a flash duration of the



order of 10 microseconds. An inbuilt electronic timer, a mechanical contactor, or suitable external high voltage may be utilized to trigger off this lamp. The instrument is suited to the analysis of any periodic movement from 100 to 30,000 cycles per minute, its maximum flashing speed being 5000 per minute. It consists of a power unit and a lamp unit, connected to each other by a 10-ft. heavy-duty cable. The power unit is permanently mounted in the case and contains power supply for the entire equipment. An "on"-"off" switch is provided in the power supply circuit. The grid and plate voltages are rectified by two No. 83 tubes and filtered. The power unit operates from a 115 v., 50-60 cycle a-c. line. A threaded insert in the base of the lamp unit permits using a standard camera tripod. The lamp unit carries all necessary flashing speed controls. The 300,000 c.p. "Type B" lamp mounted in this unit is U-shaped and has ends of unequal length to insure correct insertion. Below the reflector are sockets for the No. 58 amplifier and No. 885 timing tubes. The electronic timer comprises a "super-control" amplifier tube, Type 58, the grid circuits of which are controlled by potentiometer resistors and a range knob. This tube periodically charges a condenser, which, when it reaches the proper potential, causes the grid of a gas-filled timing tube, Type 885, to permit a discharge to pass through its plate circuit. This circuit includes the primary of a special spark coil, whose secondary lead touches the top of the Type B lamp. This lamp is continuously supplied with filtered direct current from the power unit, but this is sufficient to cause a flash only when the spark coil is energized. The lamp can be flashed by a suitable external source of high voltage such as an automobile ignition system. This requires only the lamp unit and the power unit, and does not require the contactor. The contactor (an auxiliary piece of equipment, which requires both the lamp unit and the power unit for operation) may be used in some cases instead of the electronic timer. It provides a rapid electrical make and break, is driven mechanically (not faster than 5000 r.p.m.) by the machine being viewed, and can be used instead of electronic timing, by plugging it at the jack provided in the lamp unit. Phase relations can be changed by simply turning its handle, without disengaging its rubber tip from the machine. *Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

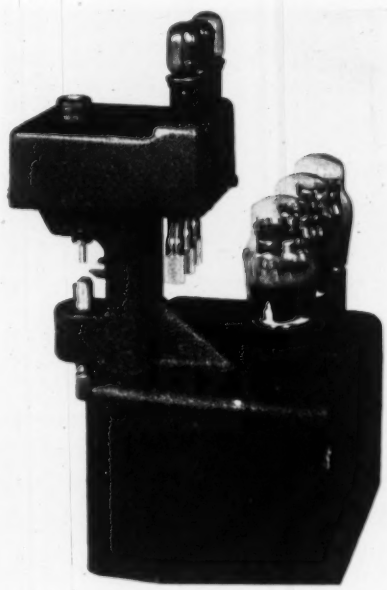
Noise Meter

The "RA-142 Noise Meter" is designed to meet the tentative Standard of the American Standards Ass'n. Amplifier: Five stage resistance-transformer coupled type having essentially flat frequency response characteristic and a gain of approximately 115 db at 1000 c.p.s. Designed to insure stability and freedom from microphonic disturbance. Maximum level handled in amplifier is within overload limit of tubes used, insuring against non-linearity from this source. Calibrating oscillator: Frequency, 600 cycles per second. Output level measured on indicating instrument in terms of voltage drop across stable calibrating receiver. Microphone—Western Electric 618-A Transmitter: Standard studio type of moving coil microphone. Diameter 3¼", weight approx. 2 lbs. Operates into 30-ohm impedance. Attenuator: Potentiometer type, located in grid circuit of second tube. 13 steps—5 db each. Has positive detent and large rotating dial. Readings not be affected by attenuator noise. Indicating Instrument: Weston made; has ballistic characteristic similar to car as specified by A.S.A. Range: 20 to 120 db. Reference Level: 10-16 watts at 1000 cycles per second. Frequency Weighting: Ear characteristic for sounds of 40 db loudness per A.S.A. specification. Weighting can be switched out to obtain essentially flat frequency response when required. Ballistic Characteristic: Based on Bekesy—full scale deflection in 0.2 seconds—less than 0.5 db over-travel. Vacuum Tubes: Standard commercial types. Carrying case measures 19½" x 12¾" x 6½". Weight complete with batteries 34 lbs. *—Electrical Research Products, Inc., 250 W. 57th St., New York City.*



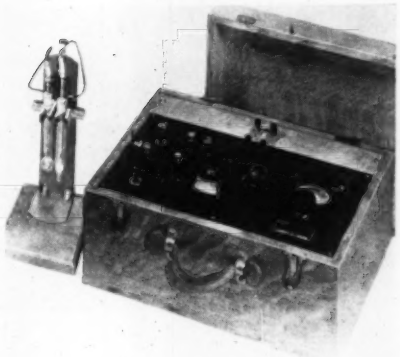
Electronic Gage

New "Model LR2 Semi-automatic Gage" is designed for manual feed, takes work <1" diam. and classifies into four sizes, the indications being by "Inspectron" vacuum-relay operated lights. For example, in checking piston pins, the station settings would be as follows: no light—under 1.0000"; one light—1.0000" to 1.0001"; two lights—1.0001" to 1.0002"; three lights—oversize. Sensitivity being 0.000002", setting to 0.00001" is readily made by means of standard blocks, which are used also from time to time to verify settings and operation of lights. Three micrometer heads at the back of the gage simplify changes of settings. The gage is provided with an adjustable regulator for spindle pressure and with an adjustable anvil and spindle. The major adjustments can be locked in by the supervising inspector. The spindle is ⅜" in diameter and the measuring similar to the standard pocket micrometer: spindle pressure can be increased without injuring the face of the ground work but enough to go through "fur" or "feather edge" of cylindrical ground pieces that do not give true readings on light-pressure indicators. The gage is provided either with hardened or tungsten carbide tipped spindle and anvil; operates on 110-volt a. c., 50 or 60 cycles; is manufactured under U. S. Patents 1980816 and 1963554, other patents pending. *—Electronic Inspection Laboratories, 663 Bangor Building, Cleveland, Ohio.*



Potentiometer-Electrometer

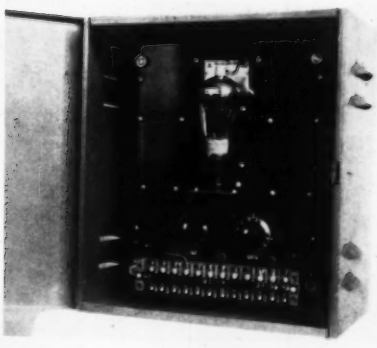
This new self-contained-portable unit, for measuring pH and oxidation-reduction potentials with any tpe of electrode, is particularly convenient where the



overall accuracy of any electrode is checked at intervals against a hydrogen electrode. It has ample sensitivity for the glass electrode and ample range for any other type of electrode. The indicator can be used where ambient relative humidity is as high as 95%. A thermionic tube makes possible the use of a pointer galvanometer (instead of a separate laboratory galvanometer, with lamp and scale). Range is 0 to 1100 millivolts; limit of error 0.2% of range; unit sensivity with the L&N glass electrode, 0.03 pH. Case dimensions 19" x 13" x 12". Current is supplied by No. 950 flashlight dry cells which fit into a compartment in the box. — *Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.*

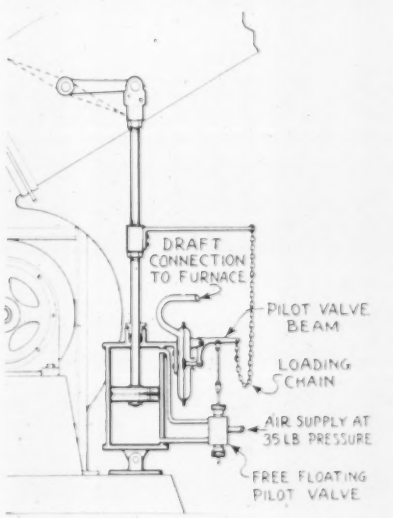
Angle Switching for Synchronous Motors

For automatically controlling the "pulling-into-step" process a newly developed high-speed synchronizing equipment consisting of inductive generators on the motor shafts, associated with grid glow type tubes and high-speed relays in the field closing circuit, can be used in conjunction with synchronous motor control of the standard type. The control functions in the ordinary manner up to the point of applying the excitation voltage. Instead of closing the field contactor at that point, the high-speed synchronizing equipment is energized. This in turn applies the excitation to the motor the first time the rotors of the two machines are in the correct angular position relative to each other. For example, a typical application is for control of four 400 h-p. synchronous motors driving 1-cyl. compressors; these were arranged in pairs and the control so designed that either motor could be started first and the second synchronized at the desired crank position. Another application is in cement mills, driven by 800- and 900-h-p., 720-r.p.m. motors, where the torque delivered through the gears which couple the motor to the load should not reverse during the synchronizing period. There also is a limit on the maximum value of positive torque. By tests under load conditions the angle switching equipment was adjusted so that the desired torques were obtained. In addition to increasing the torque against which a motor is certain to synchronize, it is said that angle switching may be used to advantage for other purposes. — *Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*



Draft Controller

A complete self-contained furnace draft controller requiring only a draft connection to the furnace and a supply of compressed air at approximately 35 lbs./in.² is announced. This controller measures furnace draft by a large sensitive diaphragm, the movement of which actuates an air pilot valve admitting pressure to one end or the other of a drive cylinder until the damper position or fan speed has been changed sufficiently to restorer furnace draft to the desired value. For example, in the diagrams, an increase in furnace draft, and a corresponding slight movement of the diaphragm to the left, moves the pilot stem downward, admitting pressure under the piston, which in turn moves upward and opens the damper. This movement diminishes the weight of chain supported by the pilot valve beam until the diaphragm force is exactly balanced and the pilot valve is returned to its neutral position. The chain loading device provides a simple and accurate means of applying a counter-force against the diaphragm which is finely graduated with the movement of the control drive. When this counter-force exactly balances the force produced by the furnace draft on the diaphragm, no further movement of the controller occurs. The Bailey Draft Controller may be applied either to the forced draft or the uptake draft as desired. Since it requires only compressed air and a draft connection to the furnace, it functions independently of other control equipment. — *Bailey Meter Co., 1071 Ivanhoe Rd., Cleveland, Ohio.*



Enclosed Circuit Breakers

Enclosed "Type AB-F Flipon" 15 to 50-amp. circuit breakers for automatic fuseless protection and control for lighting circuits, single-phase motor circuits,

and similar electrical circuits are announced. All conductors forming the interior network for light and power, from the service to the final branch circuit can be protected by "Nofuse De-ion" circuit breakers. The breakers are operable in any position without undue flash or noise. Automatic tripping is quick-break and independent of their manual operation, which is quick-make, quick-break, toggle type. The mechanism is corrosion-resistant, the contacts are non-welding and of the butt type. Contact pressure is uniform until released by toggle, both for manual and automatic operation. Automatic quick-break overcurrent operation is accomplished with inverse time lag by means of thermally actuated bi-metals. Action of overcurrent tripping mechanism is indicated by operating handle which has three positions, "on" "off" "tripped." The handle is operable from the front, trip free of the mechanism, and all multipole circuit breakers have common handle, common trip. Calibration is sealed and non-tamperable. Circuit breaker mechanism is totally enclosed in molded composition. Left-hand photo shows general-purpose and breach circuit 2-pole box with flush cover; right-hand photo shows weatherproof box complete, 2- and 3-wire solid neutral. — *Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

Self-regulating Battery Charger Without Moving Parts

Maintaining a constant voltage at the battery terminals of 2.15 volts per cell regardless of changes in the load or in the line voltage, requiring no maintenance or replacement and containing no moving parts, this new "Rectox" charger utilizes a new principle of regulation (involving no contactors, solenoids, or moving elements of any kind) whereby battery voltage is maintained at the required value within ± 1.75% with no attention other than adjustments for rectifier units. With constant line voltage available, the battery voltage will not go beyond the limits of 2.13 and 2.17 volts per cell. This type of charger has so far been developed only in the 24-cell class. It consists of a main, two-winding transformer and "Rectox" for supplying the battery charging current, together with auxiliary magnetically-operated control circuits. — *Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*